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DEMONSTRATIONS

OF

DISEASES IN THE CHEST,

ETC.

DEMONSTRATIONS

OF

DISEASES IN THE CHEST,

AND THEIR

PHYSICAL DIAGNOSIS.

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LICENTIATE OF THE ROYAL COLLEGE OF PHYSICIANS, ETC., ETC.

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TO

SIR DAVID BREWSTER, K.H., F.R.S.,

ETC., ETC., ETC.

MY DEAR SIR DAVID,

Permit me the pleasure of dedicating this work to you, in remembrance of the interest you expressed in the application of acoustics to the detection of disease; and as a slight token of my admiration of those illustrious researches and discoveries which must for ever associate your name with the history of natural science.

Believe me always,

Sincerely yours,

HORACE DOBELL.

PREFACE.

THE plan of these Demonstrations had its origin in the difficulties I experienced during my own early studies, in associating physical signs with the structural changes upon which they depend. Difficulties which were at length overcome by making drawings of the principal diseases as specimens occurred in the pathological theatre, and attaching to each a concise statement of its physical signs.

Seeing, from year to year, that these difficulties are felt more or less by every student of medicine, I have been anxious to place a similar means of overcoming them within the reach of all, free from the cost of time and labour at which the advantage was procured for myself.

My original drawings were but roughly made in the hurry of a student's life—they have therefore been cast aside, and their plan, only, retained in this work, the plates of which are taken from fresh specimens of disease, and have been executed by a skilful and practised artist.

In the pages which treat of acoustics, I have attempted to collect, in a simple and intelligent form, the principles upon which the physical diagnosis of disease within the chest is based, freely illustrating them with examples, in order more closely to connect the theories of the science with the practice of the art. The succeeding chapters are principally occupied with dissertations on the plates, and directions for educating the organs of sense to appreciate the physical signs of disease.

My endeavour has been throughout to produce a short, simple, and strictly practical work, which should, if possible, omit nothing absolutely essential to a fundamental knowledge of the subject, and yet contain nothing that could safely be omitted. I must confess, however, that the difficulties I have encountered on my way leave me no hope of having kept this happy middle course without digressions on one side or the other.

When I have ventured to make definite statements on subjects fairly open to discussion, I trust to be acquitted of presumption, on the grounds that these subjects could not be left unnoticed, while the objects and limits of my book precluded the introduction of lengthy arguments.

I cannot close these remarks without expressing my best thanks to those friends who have so kindly given me their assistance; especially are they due to Dr. Herbert Davies for the opportunities of observation which he has afforded me, during the last ten years, at the Royal Infirmary for Diseases of the Chest; to Mr. Callender, the accomplished Demonstrator of Pathological Anatomy at St. Bartholomew's

Hospital, for his help in selecting specimens for the plates; and to Mr. Holden, for the drawing of the normal position of the lungs and bronchial tubes.

I feel also that my thanks are due to the many authors whom I have consulted, but particularly to Dr. Walshe, Dr. J. Hughes Bennett, and Dr. Davies, for the advantages I have derived from the works so freely quoted under the head of Terminology.

LONDON; *July 30th*, 1858.

LIST OF ILLUSTRATIONS.

Coloured Plates.

PLATE PAGE
I. Consolidations . 69

FIGURE.
1. Isolated (miliary) interstitial tuberculous granulations.
2. Conglomerated interstitial tuberculous granulations.
3. Infiltrated tubercle.
4. Apoplexy of the lung after coagulation.

II. Consolidations . . . 70
5. Healed cavities. Fibro-cellular cicatrices and chalky concretions.
6. First stage of pneumonia.
7. Second stage of pneumonia.
8. Second stage of pneumonia passing into the third.

III. Consolidations 71
9. Medullary cancer.
10. Hard cancer.
11. Melanoid cancer.
12. Indurated lung, the effect of pneumonia.

IV. Liquefactions 83
13. Second stage of acute bronchitis.
14. Chronic bronchitis.
15. Third stage of pneumonia.

V. Liquefactions 84
16. Second stage of tuberculous disease.
17. Apoplectic coagula in the lungs, softening.
18. Apoplexy of the lung before coagulation, with and without laceration.

VI. Excavations 80
19. A large empty tuberculous cavity, with reflecting walls, free bronchial communication, and surrounding lung consolidated.
20. A similar cavity containing secretion.
21. A very superficial cavity full of air.

LIST OF ILLUSTRATIONS.

Coloured Plates.

PLATE — PAGE

I. Consolidations 69

FIGURE.

1. Isolated (miliary) interstitial tuberculous granulations.
2. Conglomerated interstitial tuberculous granulations.
3. Infiltrated tubercle.
4. Apoplexy of the lung, after coagulation.

II. Consolidations 70

5. Healed cavities. Fibro-cellular cicatrices and chalky concretions.
6. First stage of pneumonia.
7. Second stage of pneumonia.
8. Second stage of pneumonia passing into the third.

III. Consolidations 71

9. Medullary cancer.
10. Hard cancer.
11. Melanoid cancer.
12. Indurated lung, the effect of pneumonia.

IV. Liquefactions 83

13. Second stage of acute bronchitis.
14. Chronic bronchitis.
15. Third stage of pneumonia.

V. Liquefactions 84

16. Second stage of tuberculous disease.
17. Apoplectic coagula in the lungs, softening.
18. Apoplexy of the lung before coagulation, with and without laceration.

VI. Excavations 89

19. A large empty tuberculous cavity, with reflecting walls, free bronchial communication, and surrounding lung consolidated.
20. A similar cavity containing secretion.
21. A very superficial cavity full of air.

PLATE PAGE

VII. Excavations 90
FIGURE
22. Small tuberculous cavities beneath a stratum of normal lung
23. A large tuberculous cavity beneath a thick stratum of densely consolidated lung.
24. Emphysema (vesicular.)

VIII. Excavations 91
25. Bronchiectasis.
26. A gangrenous cavity.
27. A pneumonic abscess, partly emptied.

IX. Pleurisy, &c. 101
28. Normal lung, showing the interior of the bronchial tubes.
29. First stage of acute bronchitis.
30. First stage of acute pleurisy.
31. Second stage of acute pleurisy.
32. Third stage of acute pleurisy. Compressed and displaced lung.

X. Pneumothorax, &c. 102
33. Pneumothorax.
34. The pathological causes and effects of Pneumothorax.
35. Empyema with Pneumothorax.

WOODCUTS.

FIGURE PAGE
1. Interfering waves 16
2. Consenting waves 16
3. Reflection from curved surfaces 19
4. Respiratory movements in the male . . . 55
5. Respiratory movements in the female , . . . 55
6. Normal position of the lungs and bronchial tubes midway between inspiration and expiration 60

CONTENTS.

CHAPTER I.

PAGE

Simplicity of the practice of Auscultation and Percussion—Examples of its application by labourers and artizans—The difficulties of the medical student compared with those of the artizan—Object of the arrangement of the Plates—ACOUSTICS—Correlation of motion, time, number, and the properties of matter—Density—Elasticity—Vibration—Sonorous vibration—Sensibility of the ear to appreciate the rate of vibration—Waves of condensation and rarefaction—Impressions on the retina and on the auditory nerve—Experiments, illustrating the distinction between musical and unmusical sounds—Propositions 1 to 4 . . . 1—9

CHAPTER II.

Some medium essential to the manifestation of sound—Conditions under which the impact of matter produces sound—Examples—Conduction of sound—Conditions influencing this—Density—Homogeneity—Velocity—Phases of Vibration—Interference—Examples—Superposition of small sonorous Vibrations—Examples—Reflection from plane and curved surfaces—Examples—Reciprocation, unison-resonance, consonance, echo—Table of comparison by Walshe—Examples—Skoda's theory of consonance—Metallic-tinkling—Gutta cadens—Amphoric echo—Propositions 5 to 10 . . . . . . 10—25

CHAPTER III.

Substantive distinctions between individual sounds, simple and compound—Musical and unmusical sounds—Duration, intensity, volume, rhythm—Dr. S. Alison's observations—Adjective dis-

PAGE

tinctions between sounds—Pitch—Relations of pitch to density, elasticity, and rate of vibration—Examples—Musical intervals—Timbre, structural and functional conditions influencing it; descriptive terms—Examples—Names of individual sounds used adjectively—Register of the Voice—Propositions 11 to 17 . 26—35

CHAPTER IV.

Sounds must be heard to be rightly appreciated or remembered—Three conditions essential to a knowledge of Auscultation—the means of fulfilling these—Terminology—Importance of simplicity in nomenclature—Terms used by Dr. H. Davies, Dr. Walshe, Dr. J. H. Bennett—Terms adopted in the Plates of this work . 36—48

CHAPTER V.

Systematic restrictions now cast aside—Clinical utility and convenience followed in future—Important assistance to be gained from a kind of "ready reckoning" learned by experience—Suggestions to facilitate its acquirement—Basis of safe diagnosis—Inspection and topography—Systems of Dr. Davies, Dr. Sibson, Dr. C. J. B. Williams—Objections to these and others—Importance of a basis on universal facts, such as the obvious anatomical points of the body—Objection to numerous instruments at the bedside—Simple guides in the practice of Inspection, Mensuration, Palpation, Auscultation, and Percussion—Means of most easily acquiring a knowledge of these—Sources of typical sounds—Directions for experiments on inanimate bodies to educate the ear—Suggestions for facilitating correct diagnosis . 49—68

Physical signs of consolidations . . . . 69—71

CHAPTER VI.

COROLLARIES TO PLATES.

Corollary to Plates I, II, and III—Increased vocal fremitus—Impaired percussion sound—Bronchial breathing—Prolonged expiratory murmur—Jerking inspiratory murmur—Deficient vesicular murmur—Harsh respiratory murmur—Fine crepitation—Œdema of the Lung—Small crepitation of capillary bronchitis—Diagnosis of early phthisis, precautionary remarks . . . 73—81

Physical signs of Liquefactions . . . . 83—84

COROLLARY TO PLATES IV AND V.

PAGE

Crepitation—its meaning and acoustic conditions—Coetaneous signs —Prolonged and laboured expiratory movements . 85—87

Physical signs of Excavations . . . . 89—91

COROLLARY TO PLATES VI, VII, VIII.—EXCAVATIONS.

Diminished chest-expansion—Vocal fremitus—Percussion sounds, dull, clear, tympanitic, metallic, normal—Cavernous sounds, conditions rendering them important—Absence of cavernous sounds no proof of absence of cavity—Gurgling, if of pure character, ranks in importance with "metallic tinkling" and "amphoric echo"—Diagnosis of a cavity by considering signs in a group—Signs of emphysema discussed—Bronchiectasis, caution against mistakes in its diagnosis—"Bruit de pot fêlé," its identification 93—100

Physical signs of Normal Lung with increased function, Bronchitis, Pleuritis, Empyema, Hydrothorax . . - 101

Physical signs of Pneumothorax with Empyema . . 102

COROLLARY TO PLATES IX AND X.

Physical signs of pleuritis—Explanation of the uncertain occurrence of friction-sounds—Displacement of organs—Hydrothorax—Importance of vocal fremitus; its disappearance explained—Absence of vesicular sounds, and uncertain occurrence of bronchial sounds explained—Varieties of friction-sound explained—Old adhesions—Pneumothorax—Elastic chest-wall—Tympanitic resonance—Influence of compression on the percussion sound of confined air or gas—Metallic tinkling; amphoric echo; gutta cadens; their acoustic conditions and distinctions—Pathological causes of pneumothorax—Supplementary, puerile, or compensatory respiration, a sign for alarm—First stage of bronchitis; its signs—Rhonchus, sibilus; their explanation . . 103—11

CHAPTER VII.

CONCLUDING REMARKS.

General practical lesson to be learned from the plates—Qualifications of a physician—The wisdom of suspending judgment if the evidence is not complete—Insufficiency of physical signs as the sole basis of diagnosis—Examples of groups of pathological conditions requiring analysis . . . . . 112—15

DEMONSTRATIONS

OF

DISEASES IN THE CHEST.

CHAPTER I.

Simplicity of the practice of Auscultation and Percussion—Examples of its application by labourers and artizans—The difficulties of the medical student compared with those of the artizan—Object of the arrangement of the Plates—ACOUSTICS—Correlation of motion, time, number, and the properties of matter—Density—Elasticity—Vibration—Sonorous vibration—Sensibility of the ear to appreciate the rate of vibration—Waves of condensation and rarefaction—Impressions on the retina and on the auditory nerve—Experiments, illustrating the distinction between musical and unmusical sounds—Propositions 1 to 4.

THE practice of auscultation and percussion is so simple and, indeed, so instinctive, that it has been employed in nearly every department of life, when persons have desired to learn the nature of sonorous bodies or the sources of sounds, of which the causes were invisible at the time of inquiry. Thus the farmer's lad percusses the ice upon the frozen pond to learn where it lies firmly on the surface of the water, and where it is separated by a stratum of air. The joiner estimates the length of nail he will require to reach the solid joists in a plastered wall, by the degree of force with which he has to strike to elicit dulness on percussion. The tapster knows that the line of dulness on the butt corresponds with the level of its fluid contents. These are but the rudest applications of that division of auscultation, classed under the head of *percussion*.

In commerce and the arts, much nicer distinctions of sound are appreciated by the ordinary workmen and artizans. Thus the vendor of glass and china rings his wares as they are unpacked, quickly distinguishing the cracked articles by their altered tone. The money-changer discriminates between the various metals, better by the ear than by the eye. But, perhaps, the completest specimen of auscultation is that practised by watchmakers, who, by listening to the tick of a watch, learn the construction of its escapement.

It would be disgraceful indeed if sources of information, so satisfactorily applied to by the less educated classes, were neglected by the physician. Nor would it be less discreditable, did he content himself with the mere knowledge of the sounds and their practical significance, without investigating the theory of their production, and the scientific principles by which they are governed. The student of medical auscultation is, however, beset with difficulties which never cross the path of the labourers or artizans of whom we have spoken; difficulties which at once complicate and elevate the study. Their occurrence explains how it is that the watchmaker's apprentice can detect the nature of the escapement of a watch, so much more easily and positively than the student of medicine can arrive at his diagnosis of disease within the chest.

The marked difference between the positions of the two learners rests upon their respective capabilities of connecting cause and effect by actual demonstration. Cause and effect become associated in the mind, more or less closely and indelibly, in proportion as the senses are able to take cognizance of them under the same conditions at the same time; separate them by a longer interval, they lose more of their relation; surround each with a different assemblage of incidental circumstances, and it becomes a severe task to teach the mind to regard them, apart from these, in their true relationship.

In the case of the watchmaker's apprentice, the course is clear enough; he listens to the character of the watch's tick, and immediately opens the case and looks at the escapement; he hears the effect and sees the cause almost coetaneously. The medical student, on the other hand, auscults the chest, and hears a sound, perhaps, *fine crepitation*;—examines all the attendant symptoms, and thinks he has impressed the sound upon his mind; but the patient probably recovers, and he does not see its cause, and, watching the case through its other phases, he has other sounds to learn, which partly confuse the impression made by the first. This may repeatedly occur before there is a post-mortem examination of a case of pneumonia, and at last it may not be one which he has had the opportunity of ausculting during life; he studies the morbid changes in the lungs, and tries to connect them in the mind with the "fine crepitation" heard in another case; but the altered circumstances, and the interval, have deprived the sound and the disease of their natural association, and they fail to leave the impression of cause and effect. Were it practicable for some one familiar with the subject to take each student to the bedside, and say, "listen to that sound, it is fine crepitation;" and thence to conduct him to the dead-house and say, "that lung is in position, when their equilibrium is disturbed by any applied force, not sufficiently intense to produce disruption; and this restoration of equilibrium is effected, not at once, but by a series of alternating movements, by which the atoms are repeatedly approximated and separated, until at length they attain a state of rest in their normal position.

These motions are known by the names of *vibrations*, *waves*, *undulations*, or *oscillations*, according to the peculiar circumstances under which they are produced; and it is clear that, in proportion as the space allowed for this molecular approximation and separation is diminished, that is, in proportion to *density*, these alternating movements must be restricted in their extent, and brought to a close in a shorter space of time. Thus establishing a simple inter-dependence between the density and elasticity of matter, and that relation of its oscillations to time and number, which constitutes the link between motion and sound.

That matter may vibrate without producing sound is readily learned, by watching the string of any musical instrument, the vibrations of which will be found to continue for some time after its sound has ceased; and in this simple experiment, it may also be observed that the rate of movement is very different during the sound and during the silence:—all the vibrations are isochronous, but, in the former case they are more extensive, and their movements so rapid as to be scarcely appreciable to the eye; in the latter they become more and more restricted, and their movements so slow that they are plainly seen.

But, although we may demonstrate that "when an elastic body is thrown into vibrations, having a certain degree of rapidity, sound is produced," it is not so easy to determine what is this certain degree, essential to the production of sound. There is reason to believe that some ears are capable of appreciating vibrations too slow to convey the sense of sound to others, and that vibrations too rapid to be appreciated by some are by other ears distinctly recognised. It is probable, therefore, that the results of experiments on these minute differences will always vary. It has, however, been ascertained that vibrations occurring at the rate of 24,000 per second can be recognised as sound by some delicate ears, and that a definite musical note is produced by vibrations taking place at a rate no greater than 16 per second. Some obscurity still exists as to whether each vibration, when performed at a sufficient rate, is competent to produce sound, or whether a certain number of these is essential to that result; and a question has been raised as to the portion of the vibration of which the ear takes cognizance; whether the impression of sound is conveyed by the wave of condensation or by that of rarefaction. On this latter point, there is some weight of evidence in favour of the view that the waves of rarefaction are transmitted most rapidly, and hence reach the ear the first and convey the impression of sound. With regard to the former question, it is believed that each oscillation or vibration produces a distinct sound, but that the impressions following each other in very rapid succession, the ear can distinguish nothing but a single continued and prolonged note; as in the sense of sight, a number of single objects thrown upon the retina in sufficiently rapid succession, are appreciated as only one impression. This may be illustrated by the old fashioned toy, made by marking dots upon both sides of a piece of card, and rotating it rapidly by means of strings attached to the circumference, whereupon the dots upon the two sides of the card appear to be all before the eyes at one time; or, better still, by a tee-totum while spinning rapidly, when the angles of the body are lost to the sight, and the letters on the different sides commingled, so that it looks like a circular body surrounded by a coloured band.

From this view of the phenomena of sonorous vibration, the nature of the distinction between musical and unmusical sounds seems to flow as a spontaneous conclusion into the mind—the analogy between impressions of sound upon the auditory nerve which we cannot see, and optical phenomena which we can see, assists us not a little in understanding the former. For example, if we take a teetotum before it is lettered, and rotate it rapidly, the swift recurrence of the similar white sides before the eyes gives the impression of a continuous white band. If we now make a black dot on three contiguous sides and rotate again with sufficient rapidity, the three dots will appear joined into a dark line broken at quickly recurring intervals, as the side without a dot passes before the eye. If a fourth dot be now placed upon the vacant side, and rotation again set up, a continuous line is seen round the toy. Let the dots represent sonorous vibrations, and the rate of rotation the rate of vibration; then the dark continuous line will represent a continuous sound produced by a certain number of regular vibrations; while the dark line, broken by the recurrence of the white space, will represent a sound of which the vibrations occur at irregular intervals. The first of these would be a musical note, the second an unmusical sound or noise. This, which is an illustration of musical and unmusical sounds in their crudest form, is sufficient for our present purpose; and as we are not here concerned with the principles of harmony, or with the practice of musical composition, it may be better not to confuse the ideas by entering more fully into the science of music; for whatever concerns the sonorous vibrations of matter belongs to Acoustics, of which Music is only a branch, having certain rules of its own, but subject to the laws of the general science.

Thus far the following propositions may be advanced:

1. When matter is thrown into vibrations, having a certain frequency or rate, sound is produced.
2. This frequency or rate is principally influenced by the molecular condition of the vibrating body.
3. Musical sounds are produced by equal vibrations, occurring at regular intervals, and at a certain rate.
4. Unmusical sounds are produced by vibrations which are deficient in one or more of the conditions—equality, regular recurrence, and rate.

CHAPTER II.

Some medium essential to the manifestation of sound—Conditions under which the impact of matter produces sound—Examples—Conduction of sound—Conditions influencing this —Density—Homogeneity—Velocity—Phases of Vibration—Interference—Examples—Superposition of small sonorous Vibrations—Examples—Reflection from planes and curved surfaces—Examples—Ægophony—Reciprocation, unison-resonance, consonance, echo—Table of comparison by Walshe—Examples—Skoda's theory of consonance—Metallic-tinkle—Propositions 5 to 10.

When the vibrations of matter have fulfilled all the conditions essential to the sonorous character, they have yet to be transmitted to the auditory nerve, before they become manifest as sound,—some medium must exist, capable itself of vibration, between the sonorous body and the ear. Thus, a bell rung beneath an exhausted receiver produces no audible sound, because no medium exists within the vessel to convey the sonorous vibrations to its walls. And as we have no knowledge of sound, except through the sense of hearing, it must always be treated of under two divisions :

I. The matter by the vibrations of which sound is produced.

II. The medium by which we become cognizant of its existence.

I. OF THE MATTER BY THE VIBRATIONS OF WHICH SOUND IS PRODUCED.

Sonorous vibration may be excited by any combination of circumstances, involving the impact of one mass of matter with another; and the conditions under which such impact usually occurs in producing sound may be thus enumerated :—

1. Concussion of one solid body with another.

Examples: The stroke of the physician's hand in percussing a solid organ; the foot falling on the floor; the blow of a hammer on a nail.

2. Friction between two solid bodies.

Examples: Pleural friction sound, produced by the rubbing of one roughened pleural surface against the other; the brushing of articles of clothing against the walls or furniture of an apartment; the bow of the violin upon a chord.

3. Concussion of a solid with a gaseous body through the medium of a vibratile lamina. (In these cases there is some difficulty in distinguishing between the sonorous vibrations of the air and of the vibratile lamina.)

Examples: Percussion of the chest wall over air-containing lung; percussion of the stomach or intestines when full of air or gas. The stroke of a drum-stick upon a drum, or of the hand upon a tambourine.

4. Friction between a solid and a gaseous body.

Examples: The air from the human chest upon the throat, teeth, lips, &c., in forced expiration; the passage of air in the lungs over laminæ of adhesive matter attached to the walls of bronchial tubes, or over the normal septa dividing air-passages; the propulsion of air through bronchial tubes narrowed in calibre by disease; the rustle of articles of clothing when moved suddenly and rapidly through the air; the wind rustling through the trees.

5. Concussion of a solid body with a liquid.

Examples: Succussion of the chest in hydro-pneumothorax, by which liquid is dashed against the thoracic wall. (The greater part of the sound usually heard, the gurgling part, is due to collision between the *air* and fluid, but besides this the dash of the fluid against the chest-wall may be detected.) The dash of the oar into the stream; water dropping on to a stone or plate of glass.

6. Friction between a solid and a liquid body.

Examples: The propulsion of fluid through a narrow orifice, or over a vibratile lamina; the murmur of a stream flowing through a bed of reeds.

7. Concussion of a liquid with a liquid.

Examples: Gutta cadens, produced by the falling of drops of exudation from the walls of the pleural sac in pneumothorax, into the fluid of empyema or of hydrothorax, or of drops of pus from the roof of a large tuberculous cavity into the liquid secretion on its floor; the dropping of water into a well; the splash of rain upon a pool.

8. Concussion of a gaseous with a solid body.

Examples: The air from the human chest impinging on the vocal chords in speaking or singing; *metallic tinkling*, when the air, in sudden inspiration, or in coughing, or speaking, impinges on the dense vibratile wall of a cavity in the lungs. A bell-glass, caused to ring by a sudden gust of air from a bellows upon its wall; the wind striking the chords of an Æolian harp.

9. Concussion of one gaseous body with another.

Examples: The bursting (explosion) of bubbles in the air-passages, or on the surface of secretion in cavities of the lung, when air is forced through them during respiration, producing various-sized *crepitation;* explosion generally; the bursting of bubbles on the surface of an effervescing fluid.

10. Concussion of one gaseous body with another in a confined space.

In this case, it is always difficult to distinguish between the sonorous vibrations of the wall of the confining tube or chamber, the friction sound of the gaseous body upon the solid, and the sound produced simply by the vibration of the one gaseous body excited by the impact of the other. The principal sound is produced by this impact, but it is modified by the nature of the walls confining the vibrating air or gas, the length of the tube, the open or closed condition of its ends, and several other circumstances.

Examples: The concussion of a gust of air upon the air contained within a cavity in the lung, produced by sudden inspiration through a communicating bronchial tube; a blast of wind into an organ-pipe; a pencil of ignited hydrogen gas directed up a tube containing atmospheric air.

11. Concussion of a gaseous with a liquid body.

Examples: Air drawn suddenly through a bronchus opening into a cavity in the lung containing fluid, so that the current of air shall impinge on the surface of the fluid at a right angle; blowing through a tube placed perpendicularly to the surface of water; the portion of the succussion sound, not included in No. 5—*gurgling;* it is a modification of large crepitation; but crepitation is the explosion of a bubble, as already explained, while gurgling is produced when the volume of air or gas is so great that the liquid through which it passes is made to leap up, and thus to produce concussion of a gaseous with a liquid body.

12. Friction between a gaseous and a liquid body.

Examples: When pervious bronchi open obliquely or horizontally to the surface of fluid in a cavity, the air during respiration may be driven along the face of the fluid, so as to produce a rippling without bubbles; the wind driving over the surface of a lake; water spouting forcibly through the air.

II. OF THE MEDIUM BY WHICH WE BECOME COGNIZANT OF SONOROUS VIBRATION

By whatever means sonorous vibrations are excited, the medium of communication between the vibrating body and the ear may consist of either of the forms of matter: it may be solid, viscous, liquid, or gaseous. These may be combined heterogeneously, or they may alternate with one another in various orders of succession; and the behaviour of sound in its relation to these media follows certain laws comprised under the head of *Conduction* or *Transmission.*

Sound is not transmitted with equal facility through all media, two principal conditions influencing its behaviour in this respect: 1. The *density* of the conducting medium. 2. Its *homogeneity*—the best conducting medium being matter of a certain density and perfectly homogeneous. This *certain* density is probably one exactly corresponding with that of the sonorous body. Thus, a sound produced by friction on one end of a wooden rod is best heard by applying the ear to the other end; and in this manner it may be conducted to an indefinite distance. Sound generated in water has been transmitted nine miles through the same medium; and a word spoken in a whisper has been distinctly conveyed by atmospheric air 2860 feet, the lateral diffusion of the vibrations being prevented by confining the air in a tube. It is in this way that speaking-trumpets act.

Cæteris paribus, solids conduct better than liquids, liquids better than gases, and dense gases better than those that are rare.

But audible sound, however produced, must sooner or later travel through atmospheric air; for if at no other part of its course, it must do so in passing through the ear to the auditory nerve—and in the majority of instances, sounds transmitted to the ear by solids or fluids have traversed air before reaching these solid or fluid conductors; and sounds conveyed by air alone have generally been produced by the vibration of some other form of matter. Hence, with the exception of sounds produced by the vibration of air and conveyed by air, an exact correspondence between the density of the sonorous body and its conducting media is not attainable; and the conducting media fail to that extent in the second element of perfect conduction—homogeneity. Want of homogeneity interferes with the perfect transmission of sound, chiefly for the following reasons:—

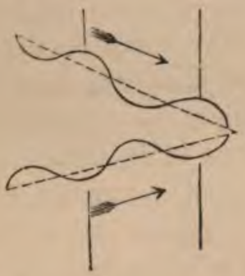
1. In some portion of the heterogeneous medium, there must be a want of correspondence in density with that of the sonorous body.

2. All sounds in traversing given distances through the *same medium* are propagated with equal rapidity, and hence, when the vibrations reach the ear, they will all be in the same phase (fig. 2). But, in traversing different media, the velocity may be altered; thus, supposing the velocity through air to be 1, it will be 4·5 through water, through cast iron 10, through wood 11. Therefore, in being transmitted through a heterogeneous medium, the vibrations will

reach their destination in different phases—the phases of elevation of some corresponding with the phases of depression of others—the effect being that they mutually *interfere* with each other, and either annihilate or materially check the sound through what is emphatically called *interference* (fig. 1).

Fig. 1.

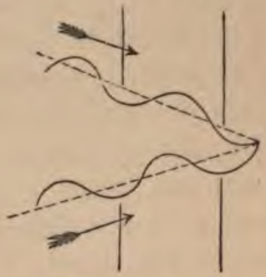
Phases of Elevation.



Phases of Depression.

Fig. 2.

Phases of Depression.



Phases of Depression.

Example of conduction altered by density.—When a portion of healthy air-containing lung lying over a bronchial tube is ausculted, the sounds in the bronchus are not audible; but if the same portion of lung-substance becomes solidified in any way, as by the deposit of inflammatory exudation or tubercle, the sounds of the bronchus are conducted to the ear of the auscultor through the tissue now increased in density.

Example of conduction influenced by changes in homogeneity.—Any substance in which solid material and air succeed one another repeatedly, as in cotton wool. If a watch is placed under a light well-shaken pillow, its sounds may be scarcely transmitted to the ear placed above; but if the air is pressed from between the down, and the pillow thus rendered more homogeneous, the tick of the watch may be plainly heard through it.

A glass half filled with solution of bicarbonate of potass will ring when struck upon its edge, the vibrations being freely conducted across the homogeneous fluid; but the sound is deadened as often as effervescence is excited by dropping in a crystal of citric acid, the bubbles of gas in the fluid destroying for the time its homogeneity.

The imperfect conduction of sound through healthy air-containing vesicular lung-substance, is an example of the same kind, want of homogeneity adding to its want of density in preventing the conduction to its surface of sounds generated beneath it. It is thus that a cavity may be concealed from the auscultor by a stratum of healthy lung, whereas the sounds of the bronchi may generally be heard in health over the first bone of the sternum, and between the scapulæ on either side of the third dorsal vertebra, because they are separated from the ear by structures more homogeneous. (See p. 14, and fig. vi.)

In connexion with conduction of sound must be noticed the *superposition of small sonorous vibrations*—an application to acoustics of the law of the superposition of small motions; viz., "If the particles of which a body is composed are actuated by several disturbing forces, they will obey each in the same manner as if it existed alone."

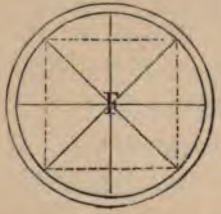
Examples: In a room full of people engaged in conversation, an attentive ear may distinguish the ticking of a watch at some distance, as clearly transmitted through the air as though the other sounds did not exist. When several delicate sounds exist simultaneously in the chest, careful observation may discriminate between them, and fine crepitation, healthy respiratory murmur, and rhonchus may be heard at the same moment from contiguous portions of lung, and each be appreciated by the ear as though it existed alone.

Sonorous vibrations during their transit through different media, in addition to being subject to the influences already mentioned, may be altered in their direction, and otherwise affected, by *Reflection*, and *Reciprocation*. "When any elastic body impinges obliquely on a plane surface, the force of restitution will, after impact, carry it away from the plane;" and in obedience to this law, sonorous vibrations, when they impinge on a plane surface, are *reflected* from it, the angles of incidence and reflection being equal, and the velocity and intensity of the sound continuing the same after as before reflection.

When a sound thus reflected reaches the ear *after* the perception of the original sound, the second, or reflected sound, constitutes an *echo*, which may be repeated as many times as parallel reflecting surfaces occur at proper distances. Examples of such multiple reflection are probably presented by the much discussed auscultatory sounds, *Ægophony* and *Tremulous-bronchophony*. The conditions essential to which would, in this case, be a laminated succession of reflecting and conducting media, holding certain relations of distance to each other. If the conducting media differ in density, the law of *Interference* already stated (p. 16) will still further modify the sounds, and assist in giving them their peculiar vibratile, or beating, character. The capricious occurrence of ægophony, and its want of exact relation to any one lesion, are consistent with this view, for such a combination of multiple reflection and interference must be purely accidental in pathological changes; at the same time, it is most likely to occur in interpleural affections complicated with pulmonary disease, a class of cases to which these sounds bear the most constant relation.

If the reflections from two parallel planes are sufficiently rapid to elude the discrimination of the ear, they may produce the impression of a single sound prolonged and reinforced. *Examples:* Reverberation of sound in empty, uncarpeted rooms. The reverberated voice-sounds, heard by auscultation, in a smooth-walled cavity in the lungs.

Fig. 3.



Reflection of sound from the walls of a cylindrical tube.

Sound is reflected by curved surfaces in the same manner as light and heat, and if the foci of the two curves meet at the same point, as at the focus of a cylindrical tube, (F. fig. 3), the sound will be rendered more intense by the double reflection. Hence the intensity of sound is found to be considerably augmented, if the vibrations are confined in tubes or cavities of any kind with curved reflecting walls. *Examples:* Sounds, in bronchial tubes running through consolidated lung by which the walls are rendered better reflectors. It is important to bear in mind, that the reflecting power of surfaces with regard to sound, differs remarkably with their texture, hardness and polish increasing, softness and want of polish diminishing it. *Examples:* the intense reverberation of sound in pulmonary cavities with hard, smooth walls; the feeble reverberation of those, the walls of which are coated with soft secretion, or consist of flocculent, disintegrated lung-substance. This intensifying of sound by reflection, is not to be confounded with the simple transmission of sound through vibrating columns of confined air, as in the tubes of speaking trumpets, spoken of at p. 15.

The combination of conduction and reflection, commonly treated of as *Reciprocation of sound*, is divisible into Unison-resonance, Consonance, and Echo; which, although not usually so distinguished, are nevertheless clearly separable. This fact, with the points of difference in each case, has been set forth by Dr. Walshe, in the following lucid and logical manner ('Practical Treatise on the Diseases of the Lungs, &c.,' 2d edition, p. 147):

"There seem to be three ways, as far as now known, in which a sound may be reinforced beyond the seat of its production;—by, what may be called, *unison-resonance,* by *consonance,* and by *echo.* In all three, reflection of sound is concerned; but the laws of that reflection are in each case different. This will be best understood from a tabular view of the differences of the phenomena. The reader will bear in mind that by unison-resonance is meant the reinforcement which occurs in the box of the guitar or violin when notes are produced from their strings, or when a musical box, instead of being held in the air, is placed on a table: by consonance is understood the reproduction of certain notes of instruments or of the voice by other instruments, standing by: by echo is meant the well-known phenomenon of repetition of sounds. All three agree in that the reinforced sound may exceed in intensity the original, and differ from this in quality."

"Original and secondary sounds, how connected in regard of—"

	Place of production.	Pitch.	Number of repetitions.	Number of notes *coetaneously* reinforced	Time of production.
In unison-resonance.	Directly connected.	All notes of the octave intensified in unison.	No true repetition; only swelling of original sound.	Never but one.	Both simultaneous.
In consonance.	Separate but near.	A single note only of the octave (or its harmonics) intensified: that note is the fundamental note of the consonating body.	Only one.	May be one, and certain of its harmonics.	Both nearly simultaneous.
In echo.	Separate and more or less distant.	Same note only.	May be several.	None.	One distinctly sequential to the other.

Example of unison-resonance: The sounding-board action of the healthy chest, pharynx, palate, and sinuses of the sphenoid and ethmoid bones.

Example of consonance: If the gamut is run with the voice at the mouth of an empty water-caraft, *one note* only of the octave is considerably reinforced, and this takes place by consonance within the cavity.

The essential conditions of consonance in a tube or cavity being, that its dimensions and form shall hold a certain mathematical relationship to the tone of the original sound, it is difficult to state a satisfactory example of consonance within the chest, and, although sounds may certainly be reciprocated by consonance in the bronchial tubes, it seems most probable that such an occurrence is only the consequence of an accidental combination of circumstances. This, however, is not the opinion of Professor Skoda, whose views upon the subject are thus epitomized by his translator, Dr. Markham:

"The voice passes into the parenchyma of the lungs through the medium of the air in the trachea and the bronchial tubes, and is not propagated along their walls; it traverses healthy, as readily as it does hepatized lung, and even somewhat more readily: consequently, bronchophony does not depend upon an increase of the sound-conducting power of consolidated pulmonary tissue; moreover, when the lung is consolidated, the thoracic voice increases and diminishes in force, without any concurrent change taking place in the condition of the lung: this variation in its strength evidently results from the circumstance of the bronchial tubes being at one moment blocked up by mucus, etc., and at another freed therefrom by the cough and expectoration, etc.; if the bronchophony depended upon conduction of sound, it would be a matter of indifference whether the tubes contained air or fluids. It must not be forgotten, that, according to the ordinary laws of reflection of sound, the more solid the parenchyma the more difficult does the passage of the sound from the air into it become.

"That the air in the mouth and nasal cavities consonates with sounds formed in the larynx, is proved by the fact of the changes which the voice undergoes through opening and closing the mouth and nose, whilst the condition of the larynx remains unaltered; just in the same way does the air in the trachea and bronchial tubes consonate with the laryngeal sounds. Now, air consonates only in a confined space, and the force of the consonance depends upon the form and size of the space, and upon the nature of the walls forming it: the more solid the walls, the more completely will the sound be reflected, and the more forcible the consonance. The cause of the loud voice produced by a speaking-trumpet is well known. But the air will consonate with certain sounds only; in the trachea and bronchial tubes, it becomes consonant with the laryngeal voice, in so far as their walls have a like or an analogous character to the walls of the larynx, of the mouth, and of the nose. Within the cartilaginous walls of the trachea and the bronchial trunks, the voice consonates nearly as forcibly as in the larynx; but as the bronchial tubes divide in the lungs, they lose their cartilaginous character, becoming at last merely membranous in structure, and therefore very ill-adapted for consonance; when, therefore, the consonance is increased in these latter tubes, we may be sure, either that the membrane forming them has become very dense or cartilaginous, or that the tissue around them is condensed and deprived of air, whereby the sound-reflecting power of the tubes is increased. Of course the communication between the air in the tubes and the air in the larynx must be uninterrupted.

"The walls of a confined space frequently vibrate in unison with sounds excited within it, as do those of an organ-pipe, or of a speaking-trumpet. The larynx vibrates with every sound, and its vibrations are perceptible at a considerable distance from their point of origin; so, also, must the walls of the bronchial tubes, which are distributed through the parenchyma of the lungs, vibrate when the voice consonates within them; and the vibrations thus excited will extend to the surface of the thorax, passing through several inches of thick fleshy parts, or of fluids, and manifest themselves there as the consonating sounds of the bronchial tubes."

As distinguished from *reciprocation*, it may be well to explain in this context a combination of circumstances accompanied by sound within the chest, very likely to confuse and puzzle the observer; viz., "*metallic tinkling*," distinguished from *gutta cadens* and *amphoric echo* as pointed out hereafter. (Corollaries to Plates.) On hearing this sound, the first idea is to refer it to some form of reciprocation; for its characters are briefly these, on applying the stethoscope over some portion of the chest-wall and making the patient speak, abnormal vocal resonance of cavernous character is heard, and almost at the same time a tinkling or ringing sound, as of a half-muffled bell. If the patient coughs similar phenomena occur.

Careful examination and analysis show that this tinkling is no form of reciprocated sound.

It is not unison-resonance, for it *follows* the first sound and does not reinforce it: not consonance, for it has no fixed harmonic or unison relation to the first sound: not echo, for although it follows the first sound it is no repetition of it: and, finally, if instead of letting the patient cough or speak, he simply inspires smartly, the tinkling is produced as before. It is in fact a *new* sound, due to sonorous vibrations of the parietes of a cavity excited by the impact of a sharp gust of air either upon its margin or upon some readily vibrating portion of its inner wall, acoustically analogous to the sound of an Æolian harp string struck by a gust of wind; in which case the tone of the instrument is clearly not a reciprocation of the murmur of the breeze which excites its vibrations. (See p. 12.)

At this place we may pause again, to add the following propositions to those advanced at p. 9.

5. Sonorous vibrations may be excited by the impact of any two volumes of the same or of different forms of matter.

6. They may be transmitted or conducted by all forms of matter.

7. The facility with which they are transmitted is principally influenced by the density and homogeneity of the conducting medium.

8. All sounds are transmitted with the same velocity through the same medium.

9. Different media transmit the same sound with different velocities.

10. Sonorous vibrations, in their transmission through matter, may be subjected to reflection and reciprocation.

CHAPTER III.

Substantive distinctions between individual sounds—Musical and unmusical sounds — Duration, intensity, volume, rhythm — Adjective distinctions between sounds—Pitch—Relations of pitch to density, elasticity, and rate of vibration—Examples—Musical intervals—Timbre—Structural and functional conditions influencing it—Examples—Names of individual sounds used adjectively—Register of the Voice—Propositions 11 to 17.

HAVING traced sonorous vibrations in general, from their first excitation to the appreciation of their existence by the ear, it will be necessary to consider some of the changes in character of which sound is susceptible.

In the first place, sounds may differ as substantives, in that assemblage of individual characteristics by which the identity of any object of sense is impressed on the mind, such, for example, as that by which we distinguish one animal from another, the tastes of different articles of food, the perfumes of different flowers, the sounds of bells from those of falling water, and the like.

In this substantive existence, as individuals, sounds may be primarily divided into those that are single, produced by one continuous set of vibrations, as a "tap," or "tick," and those that are compound, produced by the conjunction of two or more single sounds, as a "rattle" or "jingle."

Scarcely separable from these substantive characteristics by which sounds are identified, are those attributes by which they are supposed to be divisible into musical and unmusical,—the crude idea of which has already been given when speaking of sonorous vibration; viz., "musical sounds are produced by equal vibrations occurring at regular intervals, and at a certain rate." "Unmusical sounds are produced by vibrations which are deficient in one or more of these elements."

But in addition to these first conditions of their existence, sounds depend upon a number of subordinate relationships for that character, by which they are appreciated as constituents of music. Thus, according to Prof. Leslie, "A musical note, far from being only a repetition of the same simple sound, should be considered as the conjunction of subordinate sounds reiterated at proportional intervals. The sweetness of this compound effect or tone appears to depend on the frequent recurrence of interior unison." Like ideas of perfection with regard to other sensations, that idea of beauty and completeness in sound, the realisation of which is supposed to constitute a musical tone, differs in different ages and different nations, and even in our own time and country. To enter into the discussion of these differences would lead us far beyond the intended limits of this work, without resulting in any practical advantage, and therefore, in treating generally of sounds, these arbitrary distinctions between their musical and unmusical characters, will be henceforth disregarded, unless specially stated to the contrary.

Independently then of musical character, any given sound may vary in *duration*, *intensity*, and *volume;* and any two or more sounds, or any compound sound, may vary in *rhythm*. These terms, although often defined in special reference to acoustics, have the same meaning to whatever department of physical science they may be applied.

Duration—refers to time in relation to existence: thus the sound produced by striking a musical string of slight tension, exists for a longer time after the concussion than that produced by a similar blow upon the same string under greater tension:—the *duration* of the first sound is longer than that of the second. This may be observed in percussion of the chest:—dull sounds, and sounds of high pitch, other things being equal, are of shorter duration than resonant sounds of lower pitch, that is, of sounds produced by the vibration of matter of less density,—as further explained under the head of *Pitch*.

Volume—refers to mass, and it is on this that sounds principally depend for their loudness.

Intensity—refers to the amount of force manifested within a unit of volume. A sound of any duration, or of any volume, may be either weak or strong according to the degree of force with which it is excited; and sounds when excited with a great degree of force, may lose their intensity before reaching the ear, by parting with their force to the impediments met with in the process of conduction. Thus, respiratory murmur in a lung the whole of which is healthy, differs from that produced in a healthy portion of a diseased lung, in its *intensity;* because the force which in health would have been expended in the respiratory action of the entire lung, is concentrated in the diseased organ upon the healthy portion; and this intense respiratory murmur may be rendered weak before it reaches the ear, by the intervention of imperfect conducting media, such as layers of adipose tissue, or of woollen clothing. In connection with the intensity of sounds, Dr. Scott Alison has lately called attention to a very interesting phenomenon capable of practical application in diagnosis. It has been long known that a very loud sound conveyed into one ear, will render the other ear insensible to sound of a weak or low character. But Dr. Alison has, by experiment, established the fact, that "no very great loudness is required, and that no very great augmentation of sound in one ear over that in the other is necessary in order to restrict the sense of hearing to one ear, and to deprive the less favoured ear of the sense of hearing which it had previously enjoyed. A moderate, yet a decided increase of intensity is all that is required to remove the sense of hearing from the less favoured ear, and to cause the more favoured organ to be alone sensible to the sound," but "it is sounds of the *same character only* which exhibit the phenomenon of restriction in virtue of moderately different intensity. The sounds must emanate from the same sounding body, or from bodies sounding similarly. A little difference in *character* will cause the experiment of restriction to fail." In order to apply this law to the detection of disease, Dr. Alison has adapted to the double ear-piece stethoscope contrived by Dr. Caman of New York, a corresponding pair of collecting cups, forming an instrument capable of conducting sounds from two distinct points, to the two ears, at the same time.

Rhythm—refers to certain relations existing between two or more successive manifestations of force, in regard to duration, intensity, volume. Thus, the varieties of rhythm in respiration, depend upon differences in the relative durations, volumes, and intensities of the inspirations, the intervals of rest and the expirations, any or either of which may be altered by disease; and this applies as much to the movements, as to the sounds of respiration.

Individual sounds, whether simple or compound, musical or unmusical, of whatever duration, intensity, volume, or rhythm, may as substantives, be subject to several qualifications; the most important of which are included under the terms *Pitch* and *Timbre.*

Next to those substantive varieties of individual character already mentioned, *alterations of pitch* present the most definite marks of distinction between different sounds. The value of these is enhanced by the great number of changes of which they are susceptible; by the intimate relation which they bear to the molecular constitution of the sonorous body; and, by their nature permitting them to identify sounds which are alike in every other particular.

We have already discussed that relation of time and number to vibration which constitutes the link between motion and sound, and traced their inter-dependence on the density and elasticity of matter, whereby an increase in the degree of these produces an increase in the rate of vibration; and, therefore, since it is clearly established as a law, that "the *pitch of sounds is in direct ratio to the number of vibrations performed by the sonorous body in a given time,*" —pitch should hold a direct relation to the density of matter. But the elasticity of a body, like its other constitutional properties, is probably dependent upon the peculiar internal structure and arrangement of the integral molecules themselves, in addition to their molecular attraction, repulsion, and compression; so that the relation between density and the rate of vibration, and consequently of pitch, is less simple than it would otherwise be, and is evidently influenced by some conditions not yet clearly understood.

Differences of *pitch* are so commonly associated with the recognised notes or tones of music that we are in danger of supposing them to be dependent on these. This, however, is not the case. The notes of music are regulated by the number of vibrations in a given time by which each is produced, and hence each note, as its rate of vibration differs, must differ in pitch: but, as every tone is separated from the next by a certain *interval*, within which there may be several sounds, each produced by a number of vibrations greater than the one tone and yet less than the next, it follows that there must be several varieties of pitch between any two notes of music. A certain number of these are recognised by musicians, and are represented by fixed ratios of the vibrations of musical strings. By tuning a string to a given note, and while it is sounding, drawing it up to the next note by gradually turning the peg of the instrument, any one who has a delicate ear may detect an infinite number of gradations in pitch between the two recognised tones. Pitch then is susceptible of infinitesimal variations, limited only by the time in which a vibration more or less is possible, and by the power of the ear to appreciate the sounds produced.

These relations of density, elasticity, rate of vibration, and pitch, are exemplified by several interesting phenomena of which advantage may be taken in physical diagnosis. Thus, *cæteris paribus*, a gaseous body, when percussed, produces a sound of lower pitch than a solid, and a solid, one of lower pitch than a liquid,—the liquid being the least compressible,—while the pitch of the gaseous body may be raised by increasing its compression. For example, percussion of the healthy chest elicits a sound of higher pitch in the region of the heart or liver than under the clavicles; and in cases where gas is collecting in the intestines, the percussion-sound rises in pitch as the distension, that is gaseous compression, increases; and it is often easier to detect slight alterations of density in the lungs by changes in the pitch of the percussion-sound, than by its other characters.

When sounds are produced by the vibrations of air contained in tubes, the same effects are obtained by changes in the length and calibre of the tubes, and by the open or closed condition of their ends, as by alterations in the tension, mass, and length of vibrating solids. Thus the voice is raised in pitch by narrowing the "rima glottidis," or by increasing the tension of the vocal ligaments; the respiratory sounds are raised in pitch when the calibre of the air-passages is reduced by an attack of spasmodic asthma; in bronchitis the rhonchi and crepitations are of higher pitch, in proportion as they are produced in tubes of smaller dimensions; and in the large bronchi the sounds may be suddenly raised in pitch, by portions of secretion or of tumid lining-membrane partially blocking up the cavity of a tube.

After sounds have been identified as substantives by their general impression on the mind, and when their intensity, volume, duration, rhythm, and pitch, have been determined; they are still susceptible of more minute analysis, according as they are possessed of certain qualities systematically included under the denomination of "*Timbre.*"

By *Timbre*, is understood the peculiar and infinitely variable character which the same sound may assume in addition to the attributes already detailed. The formation of this character appears to be principally influenced by two classes of conditions, which may be distinguished as *Structural* and *Functional*.

1. *Structural.* Those fixed conditions of form, volume, and material belonging to each apparatus for the production of sound, and which are essential to its individuality. These conditions are chiefly instrumental in imparting those characters by which sounds are identified as substantives; characters so subtle that they elude description, but, as a whole, not the less palpable to the senses. Thus, any

sound produced on the piano is distinguished from the same sound on the harp; any note on the harp is distinguished from the same note produced by the human voice. To this class of timbre, also, belong those individual qualities of the human voice due to structural peculiarities in the apparatus, viz., *basso, baritone, tenore, contralto, mezzo-soprano, soprano.*

2. The *functional* are those changeable conditions of which each apparatus is susceptible in its mode of action, and which impart to the sounds produced some peculiar features supplemental to all the others mentioned. Such as the varieties in the quality of the same note upon the same instrument struck by two different performers; the varieties of breathing and voice sounds called *pulmonary, bronchial, laryngeal;* for although the breathing and vocal apparatus enters, as a whole, into the production of all voice and breathing sounds, yet, as in each of these varieties some one or more portions of the instrument are concerned in chief, they owe their characters to functional changes.

Functional changes of timbre have been divided by musicians into two orders: *clair,* or *acute;* and *sombre,* or *grave.* In ordinary parlance or description, however, the tertiary modifications are alone noticed, and a sound is said to be *hoarse, round, liquid, silvery, wooden, metallic, hollow, tubular, amphoric, harsh, soft, dead,* (i. e., *couverte,* or *dull;*) and the human voice is said to be uttered in the *contra-bass, chest, falsetto, head, guttural, nasal,* or other timbre; without further expressing that it is first acute or grave, and not always pointing out that reference is made to the sounds of a piano, of a carriage-wheel, or of the human voice, because between the persons speaking these may be tacitly understood.

In speaking of the qualities of sounds it is necessary to point out a common cause of obscurity in description, viz. that, as the names of certain individual sounds are used adjectively, to indicate that some other sounds partake of their characters, the sounds thus qualified may be mistaken, in speaking or writing, for those that they only resemble. Thus, a crackle, also called a crackling sound, and a creak, also called a creaking sound, is each an individual sound or substantive; but a crackle may be creaking, or a creak may be crackling, in which case the words indicate only a resemblance. In this manner most of the names of individual sounds are used adjectively, and may lead to confusion if the source of fallacy is not borne in mind.

Sounds are less easily identified by varieties of timbre than by their pitch or by their general individual characteristics; but when both of these fail, recourse must be had to the more subtle distinctions.

The term *Register* is applied to systematic divisions of the human voice, regulated by the portions of the vocal apparatus supposed to be principally implicated in the production of a certain range of sounds. The lowest division or register is the *contra-bass*, the next the *chest*, the highest the *head*, and that which is intermediate between the chest and the head is called *medium* in women; while in men, who have no head voice, the range of sounds corresponding to the *medium register* of women is called *falsetto*. In each of these registers the sounds are distinguished by a certain *timbre*, as already mentioned (p. 33).

The chest voice is the basis of all vocal sounds in men, women, and children; it is that in which men always naturally speak, and in which they excel. Women and children generally speak in the medium register, but it is in the head voice that women excel, and which is employed by both women and children when uttering piercing cries. Sounds of higher pitch than any included in these registers may be produced by those inspiratory vocal efforts known as shrieks. In the physical examination of the chest, when comparing the vocal fremitus or resonance at two separate points, care should be taken that the sounds tested in each case are uttered in the same register, otherwise the comparison cannot be depended upon.

The following propositions may now be added to those advanced at p. 9 and p. 25 :

11. All sounds are possessed of a certain assemblage of characters by which they may generally be identified as individuals.

12. Any sound may differ in duration, intensity, or volume, and any compound sound, or any two or more successive sounds, may differ in rhythm.

13. If two sounds emanating from the same source, or from bodies sounding similarly, *differ from each other in intensity only*, and are separately conducted to the two ears of the same person at the same time, the sense of *hearing is restricted to the ear into which enters the more intense sound.*

14. Any sound will be altered in pitch in direct ratio to the number of vibrations performed by the sonorous body in a given time.

15. The rate of vibration of the same body, and consequently the pitch of its resulting sound, increases with the increase of its density.

16. Any sound, however otherwise characterised, may differ in timbre according to the structural and functional conditions under which it is excited.

17. In fixing sounds upon the memory, they are most easily distinguished by general characters as individuals, next by pitch, lastly by timbre.

CHAPTER IV.

Sounds must be heard to be rightly appreciated or remembered—Three conditions essential to a knowledge of Auscultation—the means of fulfilling these —Terminology—Importance of simplicity in nomenclature—Terms used by Dr. H. Davies, Dr. Walshe, Dr. J. H. Bennett—Terms adopted in the plates of this work.

Our power of embodying the idea of sound in words is so unsatisfactory, that it is utterly impossible for any care or length in description to convey a just impression of a definite tone, without resorting to comparison with some sound already familiar to the ear; hence description of sounds always resolves itself into stating that they are similar to some other sounds; and unless these happen to be familiar to the person addressed, no idea whatever will, at last, be given of the sound in question; and supposing them to be familiar, they are seldom more than approximations to the character of the sounds compared with them, and therefore they give a false impression. Hence, it should ever be borne in mind, that a *sound must be heard to be rightly appreciated or remembered.* For this reason I shall take pains to avoid attempting those descriptions of the sounds of health and of disease within the chest usually entered into by authors writing upon this subject. Instead of these I shall refer the student to the sources of sound, that he may hear them for himself,—never then to be forgotten.

He who has lost his sight traces with his fingers the letters in which some scene once familiar to his eyes is described, appreciates the form and colour of objects, and paints a landscape on the brain through the sense of touch. After the same manner, let the characters of any given sounds become familiar to the ear,—let them be inseparably associated in the mind with the acoustic conditions essential to their existence,—and let these conditions be as intimately connected with the pathological changes to which they are due, and the ear will in future be able to represent the idea of physical characters to the mind, almost as vividly as though they were transmitted through the optic nerve.

Three conditions, then, are essential to a knowledge of auscultation:

1. To understand the acoustic conditions necessary to the existence of different sounds.

2. To know these sounds when heard, and to connect them with their essential acoustic conditions so intimately, that they shall stand to the mind as the symbols of such conditions.

3. To associate the conditions, thus symbolized, with the processes of health and disease necessary to their existence in the human organism.

In the preceding pages on acoustics I have endeavoured to provide the means of fulfilling the first of these conditions.

The plates, with their descriptions and corollaries, will teach the third.

The wards of the hospital or the sick-room are the sources from which alone can be gained the means of satisfactorily fulfilling the second condition. My duty in respect to it will consist in smoothing the path to this knowledge by giving some plain directions for the education of the ear, and by pointing out the best sources for obtaining specimens of the required sounds. But, before commencing these, it will be advisable to treat of the *terms* by which physicians distinguish these sounds of health and of disease within the chest.

The primary sounds of auscultation and percussion are simple and few; but as they are susceptible of varieties in intensity, duration, volume, rhythm, pitch, and timbre, and as they may be influenced by conduction, reflection, and reciprocation, the number of subordinate sounds may be almost indefinitely increased, according to the ingenuity of the auscultor and the delicacy of his ear. Thus the student may be confused and perplexed to no purpose, for want of knowing which sounds are worthy of individual consideration, and which ought to be regarded only in groups.

A sufficient specimen and enumeration of the various sounds distinguished and named by systematic teachers of auscultation and percussion is presented in the following abstracts from the writings of Dr. J. Hughes Bennett, Dr. Herbert Davies, and Dr. Walshe.

That of Dr. Walshe appears to include all that can be rationally made out of the subject, while those of Dr. Davies and Dr. Bennett are valuable for their conciseness and brevity. In classifications and nomenclatures, *simplicity*, in its true sense, should always be a leading object; let them be as simple as possible. It must not, however, be supposed that this can be obtained by neglecting any essential differences between the characters of phenomena. The careless grouping under one name or class of essentially dissimilar facts is indicative of an obtuseness or indolence quite inconsistent with that rigid analysis which can alone secure simplicity in the arrangements of science.

TERMINOLOGY.

In describing *percussion sounds* Dr. Davies says,* "I shall adopt the divisions laid down by Professor Skoda, of Vienna, who arranges them into—"

1. A full tone, and its opposite, an empty tone.
2. A clear tone, and its opposite, a dull tone.

"We may have combinations of these :"

1. A full and clear tone.
2. A full and dull tone.
3. An empty and clear tone.
4. An empty and dull tone. (Schenkelschall, or thigh-tone of Skoda.)

Tympanitic tone.—"This sound resembles the tone obtained from a drum."

Bruit du pot fêlé.

To the sounds of auscultation Dr. Davies applies the following terms:

"*Respiratory murmur,*" *Tracheal — Bronchial — Vesicular sounds.* "Each divisible into two periods, corresponding to the times of inspiration and expiration."

Bronchophony.—"No difference of kind exists between bronchophony and pectoriloquy."

Ægophony.

Abnormal alterations of the respiratory murmur.—"The anomalies of the vesicular murmur are divisible into those of—"

Intensity
- Increased.
- Diminished.
- Absent.

Rhythm
- Prolonged expiratory murmur.
- Interrupted respiration (*respiration saccadée*).

Quality.

Bronchial respiration (bronchial murmur, tubular breathing, bronchial souffle, and blowing respiration). "No difference of kind exists between bronchial and cavernous respiration."

Râles; Rhonchi.

Dry sounds:

Rough respiration.—"We always find it associated with a prolongation of the expiratory murmur."

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* 'Lectures on the Physical Diagnosis of Diseases of the Lungs and Heart.' By Herbert Davies M.D.

Rhonchus sonorus.
Rhonchus sibilans.
Snoring.
Piping.
Whistling.
Cooing.
Chirping.
Grunting.

Moist sounds:

Rhonchus crepitans.

Rhonchus subcrepitans (*mucosus*).

Gurgling, or cavernous Râle, "depending upon the same physical cause as the subcrepitant, cannot always be distinguished from it."

Consonating Râles.—"All the modifications of the subcrepitant or gurgling sounds may, however, be propagated to, and distinctly heard in, a portion of consolidated lung, which is in free communication with the points from which the abnormal sounds proceed." "Consonating râles have the same signification as bronchial-respiration and bronchophony."

Pleuritic rubbing sounds.

Soft.
Rough (*râclement*).
"Usually heard during the act of inspiration; sometimes with the expiration."

To and fro (*frottement ascendant et descendant*), heard during inspiration and expiration.

Cavernous respiration.—"No real distinction of kind exists between cavernous and bronchial respiration; the sounds differ from each other simply in degree."

Amphoric resonance "possesses, in my opinion, a far better claim to the title of *cavernous*."

Tinctement metallique (metallic tinkling).—"Closely allied to the amphoric variety, and should be considered as a modification of it, being dependent on similar conditions and explained in the same manner."

"There is, however, a variety of the sound, by Laennec very aptly compared to the noise made by the dropping of grains of sand into a hollow metallic vessel."

"While *metallic resonance* (erroneously called metallic tinkling) is a sound by no means infrequent, the true metallic tinkling—the sound of grains of sand falling into a hollow vessel—is of extremely rare occurrence."

Succussion, or fluctuation sound.

Auscultation of the cough.
Bronchial.
Tubular.
Cavernous.
Amphoric.
Metallo-resonant.

Dr. Hughes Bennett says:[*]

Of the different sounds produced by percussion.—"I consider that all these sounds may be reduced to three elementary ones; that, in point of fact, there are only three tones occasioned by percussion, and that all the others are intermediate. These three tones are respectively dependent, 1st, on the organ containing air; 2d, on its containing fluid; and 3d, on its being formed of a dense uniform parenchymatous tissue throughout. These tones, therefore, may be termed the *tympanitic*, the *humoral*, and the *parenchymatous*. Percussion over the stomach gives the best example of the first kind of sound; over the distended bladder, of the second; and over the liver, of the third."

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[*] 'An Introduction to Clinical Medicine.' By J. H. Bennett, M.D.

"Certain modifications of these sounds occasion the *metallic* and *cracked-pot* sound."

"The terms jecoral, cardial, pulmonal, intestinal, and stomachal (M. Piorry), however, may be used to express these modifications of sound produced in percussing respectively the liver, heart, lungs, intestines, and stomach."

"*Of the sounds elicited by the pulmonary organs in health and in disease.*—I am anxious to impress upon you, that the sounds which may be heard in the lungs are like nothing but themselves."

Natural sounds:

- *Laryngeal and tracheal sounds or murmurs and pectoriloquy.*
- *Bronchial sounds or murmurs and bronchophony.*
- *Vesicular respiratory murmur.*

Alterations of the natural sounds:

- *Alterations in intensity:*
  - *Puerile respiration*, increased intensity.
  - *Feeble respiration*, diminished intensity.
  - *Complete absence of respiration.*
- *Alterations of character:*
  - *Rude or harsh.*
  - *Cavernous* (*hoarse or blowing*).
  - *Amphoric, or metallic.*
- *Alterations in position.*—"It frequently happens that the sounds which are natural to certain parts of the chest are heard distinctly, where in health they are never detected. Thus, in pneumonia, bronchial, or tubular breathing, as it is sometimes called, may be evident, where only a vesicular murmur ought to exist," &c.
- *Alterations in rhythm.*

New or abnormal sounds.—"These are of three kinds: 1st, rubbing or friction noises; 2d, moist rattles; 3d, vibrating murmurs."

Rubbing, or friction noises—"May be so fine as to resemble the rustling of the softest silk, or so coarse as to sound like the creaking of a saddle, grating, rasping, &c.; and between these two extremes you may have every intermediate shade of friction noise."

Moist rattles (*crepitating, cavernous*).—"All that it is important for you to determine is, that the sound be *moist*, and you will easily recognise that the rattles are coarse or large, in proportion to the size of the tubes or ulcers in which they are produced, and the amount of fluid present."

Dry vibrating murmurs—"May be occasioned of a fine squeaking (*sibilous murmur*), or of a hoarse snoring character (*sonorous murmur*), and between the two extremes there may be all kinds of variations, to which ingenious people have applied names."

The vocal resonance — "Occasionally presents a soft reverberating or trembling noise, like the bleating of a goat (*ægophony*)."

"Sometimes the resonance gives rise to a *metallic tinkling*, a noise similar to that caused by dropping a shot into a large metallic basin, or the note produced by rubbing a wet finger round the edge of a tumbler or glass vessel."

"I wish, then, strongly to impress upon you—

"1st. That the different sounds are only indicative of certain physical conditions of the lung, and in themselves bear no fixed relation to the so-called diseases of systematic writers.

"2d. No single acoustic sign, or combination of signs, is invariably pathognomonic of any certain pathological state,—and conversely, there is no pathological state which is invariably accompanied by any series of physical signs.

"3d. Auscultation is only *one* of the means whereby we can arrive at a just diagnosis, and should never be depended on alone."

Dr. Walshe* remarks, under the head of *Percussion:* "The amount of density is inferred from (*a*) The nature of the *sound* elicited by percussion; (*b*) The *degree of resistance*—in other words, the elasticity—of the body percussed."

"(*a*) *Sound.*—The properties of percussion sound, which, varying with the density, and some other physical conditions of the textures and materials furnishing it, possess practical importance, are—*its degree of clearness; its duration;* and *its quality.*"

"(*b*) *The degree of resistance.*—The amount of resistance varies inversely as the clearness of the percussion sound, and directly as the amount of bone in the walls."

"*Percussion in disease.*"

Alterations of sound.

1. *Statical signs.*—"The statical changes in the percussion-sound, produced

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* 'A Practical Treatise on the Diseases of the Lungs, Heart, and Aorta, &c.' By W. H. Walshe, M.D.

by disease, are comparatively few in number, and simple in nature, but the indications they furnish most precise and valuable. Concisely stated, these changes are:

"*Diminution of clearness* gradually passing into perfect dulness—the *duration* of the sound being proportionally *shortened*, and the *sense of resistance increased*."

"Increase of clearness and of duration, with decrease of resistance."

"Increase of clearness and of duration, with increase of resistance."

Alterations of quality.

Wooden type.

Hollow type, which occurs under three varieties, *tubular*, *amphoric*, *cracked-metal* (*bruit de pot fêlé*).

Tympanitic type.

"The area within which loss of resonance is detected may either be *fixed*, or *changeable with the position of the patient*."

2. *Dynamic signs.*—"The acts of inspiration and expiration modify the results of pulmonary percussion in three different manners: *a*, by altering the volume of the lungs; *b*, by altering their density; *c*, by altering the position of the heart and abdominal viscera."

The principal signs under this head are—

"Comparatively deficient increase of clearness at the close of a full inspiration on either side."

"Comparatively great diminution of clearness at the close of full expiration."

"Comparatively deficient diminution of clearness at the close of full expiration."

Auscultation.

1. *In health.*—"Two sounds, discoverable by auscultation of the breathing apparatus in the state of health, attend each act of normal respiration." "These are the *inspiratory* and *expiratory sounds*."

"The *essential* or *primary properties* of these sounds, practically considered,—those which, in their modified states especially, possess diagnostic importance,—are: *special character and quality; pitch; intensity; duration; liquidness; softness; and rhythm*."

"Although in originally establishing the varieties of morbid breathing, every respiration-sound requires to be analysed in respect of these various properties, the complexity of the matter is much less in actual practice than it seems; for experience proves that several of these properties are almost invariably altered simultaneously, and of course such *compound states* may be described for convenience sake by single phrases."

"The properties of the sounds differ in the various divisions of the respiratory organs; for each of these divisions there is a healthy type of respiration, termed *pulmonary; bronchial; tracheal; laryngeal; pharyngeal;* according to the part of the respiratory passages from which the sounds audible externally are transmitted."

2. *In disease.*—"The phenomena discoverable by auscultation of the lungs in disease are:—*modified breathing sounds;* and *adventitious sounds produced by the act of respiration.*"

"*Modified respiration-sounds.*—It is extremely rare to find one only of the primary properties of the respiratory sounds affected; in by far the greater number of cases two or more of them suffer alteration at the same time; and thus are produced compound conditions of change, which may be described as distinct species of morbid respiration, and classified as follows:"

Species of unhealthy respiration distinguished by changes of—

Duration and *intensity;* exaggerated, weak, and suppressed respiration:

Rhythm, either solely or in conjunction with other properties; jerking, and divided respiration; deferred inspiration; unfinished inspiration; altered ratio of inspiration to expiration:

"*Quality,* and, in addition, other properties; harsh and bronchial respiration, and blowing respiration, with its main varieties, simple and hollow."

Exaggerated respiration is also called "*supplementary*" and "*puerile*" by different authors.

Weak respiration has two varieties—1. *Superficial,* which may be *persistent* or *intermittent.* 2. *Deep-seated.*

Jerking respiration has two varieties—*general; partial.*

Simple blowing respiration has two varieties—*diffused; tubular.*

Hollow respiration has two varieties—*cavernous; amphoric.*

"*Adventitious sounds, produced within the thorax by the act of breathing.*"—"In these there is actual generation of new phenomena."

"These adventitious sounds may be produced in—(*a*) the air-passages, or cavities communicating with these; (*b*) the lung-substance; (*c*) the pleural cavities; (*d*) the mediastina; (*e*) the thoracic parieties; (*f*) the neighbouring organs."

Adventitious sounds originating in the air-passages.

Rhonchi or rattles.—Divided into four genera, six species, five varieties, thus:

- *Whistling*
  - High-pitched—"sibilant."
  - Low-pitched—"sonorous"—
    - Snoring.
    - Rubbing.
    - Cooing.
- *Crepitating.*
- *Crackling*
  - Dry.
  - Moist.
- *Bubbling*
  - Small.
  - Large
    - Simple.
    - Hollow (cavernous or gurgling).

"*Adventitious sounds originating in the lung-substance* (pulmonary pseudo-rhonchi)."

"If individuals, whose lungs are healthy, or diseased only at the apices, and whose breathing is habitually calm, are made suddenly to respire deeply, a peculiar, fine, dry crepitation, accompanying inspiration only, may often be detected at the bases posteriorly. But after two or three, or at most five or six, acts of respiration, it totally disappears. *This pseudo-rhonchal sound* seems to depend on the sudden and forced unfolding of air-cells, which are unaffected by the calm breathing habitual to the individual; and its only importance arises from the possibility of confounding it with *crepitant rhonchus*."

"*The pulmonary compression pseudo-rhonchus*, which consists of a series of fine, very dry crepiti, evolved at a peculiarly slow drawling pace, variable in number, but generally very numerous, and commencing towards the close of inspiration, or in some cases, apparently, when this movement has almost ceased."

"*Adventitious sounds in the pleuræ*."

Pleural friction sounds—Grazing.
Rubbing.
Grating.
Creaking.
Rumbling.

Pleural pseudo-rhonchi.—"Moist sounds, rhonchoid in properties, are producible whenever *adventitious tissue within the pleura is infiltrated with serosity, and the movements* of the chest continue free."

These sounds occur in two forms—Squashy.
Crackling.

"*Adventitious sounds in the mediastina*."

"Crepitation, inspiratory and expiratory, of variable degrees of dryness, abundance, and size, audible in forced respiration only, or in calm breathing, constant or intermittent, disappearing after a few chest-expansions, or continuing through a long examination, is sometimes to be discovered over the sternum, generally or partially, while it is completely wanting over the contiguous portions of lung."

"When the cellular tissue is infiltrated with serosity and air, the production of such sound through the movements of the chest is quite intelligible."

"This pseudo-rhonchus derives its clinical interest from the likelihood of its being mistaken for the crepitant rhonchus of marginal pneumonia."

"*Adventitious sounds in the thoracic parietes*."

"Various sounds, generated in the framework of the thorax and its integuments by the breathing movements, aided or not by the pressure of the stethoscope, derive interest from the chance of their being confounded with intra-thoracic sounds." "There is scarcely a form of pulmonary morbid sound that may not be thus simulated."

"*Adventitious sounds produced in neighbouring organs.*"—The rhonchoid noise, caused by swallowing saliva, and by intestinal borborygmi; the bursting of bubbles within a stomach distended with gas.

Resonance of the voice.

In health.—Natural—laryngophony:
" tracheophony:
" bronchophony.

In disease.—"The natural vocal resonance may be diminished or increased in intensity without or with alteration in quality. Its perversions may be arranged thus:"—

Diminished intensity { Weak.
Suppressed.

Increased intensity { Exaggerated.
Bronchophony—{ Simple.
Pectoriloquous, amphoric.
Ægophonic.

Resonance of the cough.

In health.

In disease.—"The modified states of the pulmonary cough, which occur in disease," are the—Bronchial,
Cavernous,
Amphoric.

Phenomena common to the respiratory sounds, to rhonchi, and to the resonance of the voice and cough.

"Differing from all the morbid conditions hitherto considered, the phenomena termed *amphoric echo* and *metallic tinkling* attend the acts of breathing, of coughing, and of speaking.

Sounds and murmurs of the heart, as transmitted through the substance of the lungs.

Succussion.—"Produced by abrupt collision of air and liquid in an echoing space of large dimensions."

Theoretically, it is of little consequence what terms are chosen to identify certain things, provided that their meaning is clearly understood by those by whom, and for whom, they are used. But in the practical application of any science or art, it is of the greatest consequence to use as few terms as possible, and to choose those which are plain, and easily remembered. In the descriptions of the plates of this work this fact has been kept in view, and, therefore, instead of selecting terms because they might be most euphonious, or because their etymology proved to be most consistent with their application to particular things, I have chosen those which I find most familiar in the mouths of men engaged in the practice of correct auscultation, and which, I believe, most students will find retaining a place in their own vocabularies after a few years of active public or private practice.

They are few in number and most of them short, thus:

1. Respiratory murmur $\left\{\begin{array}{l}\text{Inspiratory.}\\ \text{Expiratory.}\end{array}\right\}\left\{\begin{array}{l}\text{Harsh.}\\ \text{Weak.}\\ \text{Jerking.}\\ \text{Supplemental.}\end{array}\right.$

$\left.\begin{array}{l}\text{2. Bronchial}\\ \text{3. Cavernous}\end{array}\right\}$ breathing, cough or voice.

$\left.\begin{array}{l}\text{4. Rhonchus}\\ \text{5. Sibilus}\end{array}\right\}$ Used for "sonorous rhonchus" and "sibilant rhonchus."

6. Crepitation $\left\{\begin{array}{l}\text{Large}\\ \text{Small}\end{array}\right\}$ Used for "subcrepitant rhonchus."

7. Fine crepitation, used for "crepitant rhonchus."
8. Gurgling.
9. Friction sound, of various characters.
10. Gutta cadens, commonly called metallic tinkling.
11. Metallic tinkling, do. do.
12. Amphoric echo.

$\left.\begin{array}{l}\text{13. Bruit de pot fêlé.}\\ \text{14. Ægophony.}\end{array}\right\}$ Retained only because they have become familiar as names for certain sounds.

15. Succussion sound.
16. Percussion sound, normal.
17. " " impaired.
18. " " dull.
19. " " amphoric.
20. " " tympanitic.
21. " " metallic.
22. Vocal fremitus.
23. Rhonchal fremitus.

Any further varieties in the general characters, the pitch, the timbre, the reciprocation, &c., of these sounds, may be described in appropriate terms (see Chap. III) by the observer, and should be mentioned as something supplemental to the more usual characteristics. In drawing up the descriptions to the plates contained in this work, it was thought that to dwell upon these minor modifications would only confuse the more important signs: as far as practicable, therefore, they are omitted.

CHAPTER V.

Systematic restrictions now cast aside—Clinical utility and convenience followed in future—Important assistance to be gained from a kind of "ready reckoning" learned by experience—Suggestions to facilitate its acquirement—Inspection and topography—Systems of Dr. Davies, Dr. Sibson, Dr. C. J. B. Williams—Objections to these and others—Importance of a basis on universal facts, such as the obvious anatomical points of the body —Objection to numerous instruments at the bedside—Simple guides in the practice of Inspection—Mensuration—Palpation—Auscultation and Percussion—Means of most easily acquiring a knowledge of these—Sources of typical sounds—Directions for experiments on inanimate bodies to educate the ear—Suggestions for facilitating correct diagnosis.

HITHERTO we have been restricted to a systematic consideration of our subject in its different divisions, that the mind might clearly appreciate the theories and nomenclature of phenomena; in the same manner as in teaching a person to read, we first make him acquainted with the forms and names of individual letters placed in alphabetical succession, and with the particular value of each in relation to sound. If I have succeeded in thus making intelligible and impressing on the memory the acoustic conditions essential to the existence and appreciation of the principal sounds of auscultation, we may now cast off the restrictions of systems and classifications, and henceforth take clinical utility and convenience alone for our guide.

The facts and principles already learned must be ever

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fixed in the mind, as our alphabet and grammar, to which we can refer in case of need; for as in the earliest attempts to read, after learning the alphabet, it is difficult to recognise the letters now removed from their familiar order of succession; and as in the first attempts to speak a new language, the grammar of which we know by heart, we find ourselves frequently at a loss for the inflections of words, and are obliged to decline and conjugate them mentally to find a required case or tense; so do we find most remarkably in clinical experience, that signs and symptoms perfectly familiar to us in description, in systematic order, and in theoretic meaning, puzzle and elude identification when first met with in practice, out of their classes, amidst new associations, or variously masked by combination.

Even the most precise arithmeticians, when called upon for sudden mental calculations, are obliged to adopt some plan of "*ready reckoning*;" and something like this assistance is also needed at the bedside—where we are so often called upon to make sudden and important deductions—that we may seize upon the diagnostic features of disease, and place landmarks for the separation of group from group. To do this well is one of the chief acquirements of experience, and can be thoroughly learned only by the observation of disease; but I hope to be able to facilitate its acquirement by the following suggestions, and to fulfil the promise made at p. 37, by giving some directions by which to smooth the path of clinical investigation into the physical signs of disease within the chest.

And first of Inspection.

Observation of changes in the form or movements of the chest is of great use in diagnosis, because it may, at a glance, lead the mind to an appropriate set of ideas relative to the seat of disease, and thus facilitate and give point to the further examination of the patient. This is within the proper sphere of inspection; it should be one of our first guides in a careful physical investigation,—as the traveller on first entering a new locality takes a general survey of the place to learn the cardinal points, and the general bearings of the various pathways, before proceeding on any one of them for more minute exploration.

It is certainly possible to prosecute inspection with such analytical detail, as to form, in some cases, a fair diagnosis from it alone, as it is also possible for a musician to play a whole symphony upon one chord of his instrument; but this sort of "harping upon one string" is what I would particularly point out for avoidance, as a very hazardous practice, subject at any moment to break down when least suspected, and at the most critical junctures. *A safe diagnosis must be based upon the conjunction of evidence from many sources.* I shall not, therefore, enter into all the details which can be worked up on the subject of inspection, but rather attempt to lay down a few common-sense directions for guidance in practice.

It has been the custom for teachers of auscultation to adopt or to contrive some plan of mapping out the chest-surface into regions and spaces, and to give names to each of these. Of such arrangements it will be sufficient to give the following examples:

Dr. Herbert Davies prefers the topographical arrangement designed by his father.

1. The clavicular region
   - Sternal.
   - Middle.
   - Humeral.
2. The anterior-superior region.
3. The superior mammary.
4. The submammary.

5. The axillary.
6. The superior-lateral.
7. The inferior-lateral.
8. The supra-spinal.
9. The infra-spinal.
10. The inter-scapular.
11. The dorsal, to which he adds
12. The supra-clavicular.

Dr. Sibson has made a very concise mapping, thus :—

- The simple regions,
  - Right pulmonic.
  - Left pulmonic.
  - Cardiac.
- The compound regions,
  - Pulmo-hepatic.
  - Pulmo-gastric.
  - Right pulmo-cardiac.
  - Left pulmo-cardiac.
  - Pulmo-vasal.

And Dr. C. J. B. Williams gives a somewhat different plan from either of these.

1. Clavicular (subclavian of Laennec).
2. Infra-clavicular (anterior-superior, Laennec).
3. Mammary.
4. Infra-mammary.
5. Superior sternal.
6. Middle sternal.
7. Inferior sternal.
8. Axillary.
9. Lateral.
10. Inferior-lateral.
11. Acromial.
12. Scapular.
13. Inter-scapular.
14. Inferior dorsal.

Many other arrangements may be found, each differing, in some respects, from the rest; and any one of these may be adopted by those who desire it, but in my opinion they had better all be rejected. The simple fact that there are so many arrangements destroys the use of any one —because the only object in making them must be to facilitate the accurate description of the site of disease. But as there are numerous plans of topography, the divisions of which differ in their limits, no accuracy of description can be obtained by their use unless we first state, in each case, the author of the arrangement followed; and then it will be necessary to give the definitions, otherwise it will only be intelligible to those who are acquainted with the same author; and at last, some further method of division must be adopted, to indicate how much, and what portion, of any region is affected.

It is of the greatest importance that the terms of science shall be clearly intelligible to as large a number of persons as possible; and hence, whenever it is practicable, they should be based upon universal facts. In the present instance, we have a basis of this kind in the *obvious anatomical points*, such as the clavicle, its two ends and middle; the scapula with its angles and spine; the sternum with its divisions; the ribs with their numbers, their angles, their cartilages, &c.; the axillæ; the nipples; the intercostal spaces with their numbers; and the spaces above and below the bones mentioned. These anatomical points, which are familiar to all, may be taken as the landmarks from and to which measurements may be made, with any degree of accuracy desired.

And by having a scale of inches marked upon the earpiece or some other part of the stethoscope, a gauge is always at hand. Other apparatus should only be *kept in* *reserve for special occasions,* to test the accuracy of more simple guides; to see a physician at the bedside constantly accompanied by a hammer, a pleximeter, and a chest-measurer, besides his stethoscope, is not only most alarming to his patient, but a pitiable admission of clumsiness in the use of natural gifts.

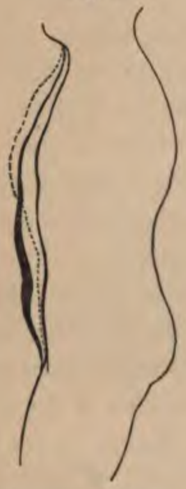
To proceed then with some simple guides to inspection. The chest may be variously deformed from causes independent of disease of the lungs or pleura. Setting these alterations aside: *if one portion of the chest is depressed,* it is due either to disease of the lung beneath, causing diminished power of expansion, and obliging the chest-wall to sink down upon it, as in tuberculous excavations; or to compression of the lung from some cause external to itself—most probably in the pleura—the depressing cause having disappeared, and the chest-wall being allowed to apply itself to the diminished lung, as after empyema.

If one portion of the chest is enlarged, it is due either to increased function of the enclosed lung, compensatory to loss of function at some other part; or to diseased increase in the size of the enclosed lung, as in emphysema; or to an accumulation of some abnormal matter in the chest, as in the case of intra-thoracic tumour, empyema, hydrothorax, or pneumothorax. When this matter is in the pleural sac, its specific gravity will influence its position.

MOVEMENTS OF THE CHEST.

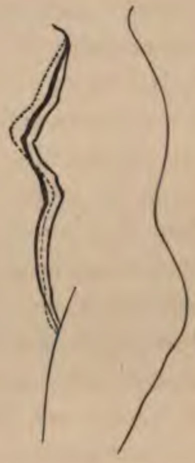
The normal respiratory movements, when carefully examined, during ordinary quiet breathing, and during forced expiration or inspiration, illustrate the principal deviations met with in disease. They are well shown in the accompanying figures (figs. 4 and 5), first designed by Mr. Hutchinson (vol. xxiv, 'Royal Med.-Chir. Trans.'), in which the outer black line indicates ordinary respiration in the two sexes, the thickness of the line representing the extent of movement; the inner black line forced expiration, and the dotted line forced inspiration.

Fig. 4.



Respiratory movements in the male.

Fig. 5.



Respiratory movements in the female.

It is here seen that in health the *thoracic* movements predominate in the female, the *abdominal* in the male. If, therefore, the breathing movements in a man should have the character of those normal to a woman, they would in him indicate disease, and be called "thoracic respiration." If, on the other hand, the breathing movements of a woman should have the character of those normal to a man, they would in her indicate disease, and be called "abdominal respiration."

Again, it is shown by the figure, that in both sexes the movement of forced inspiration predominates in the thoracic portion, as indicated by the dotted line, and that while the chest-wall is elevated, the abdomen actually recedes. This may be particularly observed when the respiration is rendered forced and labouring by disease.

MOVEMENTS OF THE CHEST IN DISEASE.

If the thoracic breathing acts are in excess, the disease is one either interfering with the action of the diaphragm, as in peritonitis; or in which the difficulty of getting air into the lungs is so great that all the muscles of the chest-wall are exerted, to attempt—by elevating it and taking off the pressure from the lungs—to induce the further expansion of those organs and the consequent ingress of air, as in some cases of bronchitis, spasmodic asthma, and the like.

If the abdominal breathing acts are in excess, the disease is one requiring the diaphragm, to compensate, by excess of action, for deficient action in the muscles of the chest,—for loss of the healthy resiliency of the lung,—or for both.

If the breathing acts are one-sided, it may be due to deficiency on one side, or to excess on the other, or to both,—the excess compensating for deficiency; and these affections may be in the chest-wall, as in intercostal neuralgia, in the pleura, or in the lung.

If the expansile action is deficient but elevation remains, the loss of power is in the lung, but it may be due to disease of its own structure, as in phthisis, or to pressure from without, as in consolidation from the pressure of inter-pleural fluid.

If the expiratory movement is undue in length, the disease is one offering an impediment to the escape of tidal air from the lungs, which may be due to actual obstruction in the tubes, or to loss of power on the part of the lung to contract upon the air and expel it. Thus it occurs in bronchitis, in tubercle, and to its greatest extent in emphysema.

If the respiratory movements are excessive in rapidity, it may be due to any disease preventing the full expansion of the lungs at each inspiration, whence an attempt is made to compensate the loss of quantity by increased rate; or to imperfectly aërated blood, or to any disease increasing the rapidity of the circulation, whence an attempt is made to supply air to the blood at a rate proportionate to the demand.

If both thoracic and abdominal breathing movements are deficient, it is due to a combination of diseases interfering with the action of the diaphragm and the external muscles of the chest, or to paralysis, or most probably to general exhaustion, in which case the deficient action will be broken at intervals by a sighing inspiration, as sufficient power accumulates for the effort.

MENSURATION.

When inspection of the chest indicates any abnormal character the amount of deviation may be estimated by *mensuration*, or if the eye fails to detect any deviation from the state of health, the correctness of inspection may be tested by the rule; hence in minute examinations mensuration must form a part.

PALPATION.

Palpation of the chest is only one of the many instances by which the importance of educating all the special senses is illustrated in medical practice. By it we may learn, among other matters—

1. The amount of resistance in percussion offered to the percuting finger.

2. The degree to which the vibrations (*fremitus*) of the thoracic organs are influenced by disease, and to which the transmission of these is increased or diminished by interposing media.

3. The presence of fluid, indicated by fluctuation.

4. The comparative temperature of different parts of the surface, and the like.

None of these means of acquiring knowledge is to be neglected, and the relation of what is learnt from one to that obtained by another is especially deserving of attention.

AUSCULTATION.

1. Learn to be perfectly certain that a respiratory murmur is healthy; that is, that it comes from vesicular lung-substance in its healthiest state, and is conducted to the chest-wall through structures in their healthiest state. You will then be able to say, what few physicians can venture upon, "There is no disease in this portion of lung which physical diagnosis is at present capable of detecting." There is only one means by which to acquire this knowledge, viz., listen to the healthy chest until its sounds are indelibly impressed upon the mind. For vesicular respiratory murmur, listen below the centre of the clavicle in front, and beneath the inferior angle of the scapula behind. Do this in an infant, a child of five to ten years old, an adult man, an adult woman, an old man, an old woman. In each case examine a thin subject and a fat one; and in each case, in immediate association with the respiratory sounds, examine those of the voice, cough, forced breathing, whispering, and percussion. After each examination think carefully over what you have heard, and return again to examine and to think until you can call up in the mind, at will, the characters of the sounds you have heard. Attach

especial value to their *essentially individual* characteristics (see p. 26).

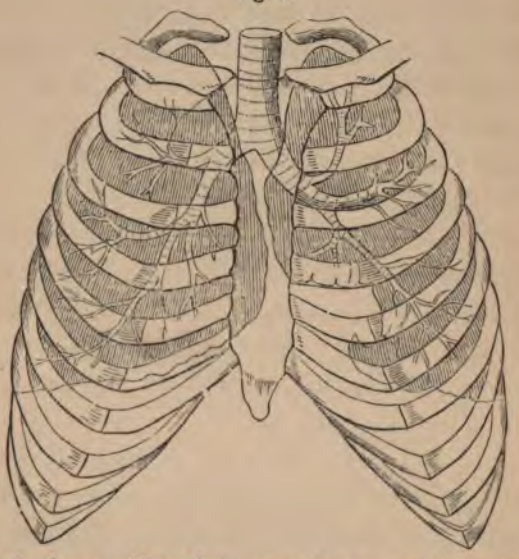
Should this appear to any one too severe a lesson, let him give up the idea of ever becoming a competent auscultator, for sooner or later he will find that there is no shorter or easier way of arriving at that end; and it will be less tedious and less disappointing to begin at first upon the sure road. It is astonishing how much you have learned, negatively and positively, when you know healthy vesicular sounds under their typical varieties. It is the most delicate point in the whole practice of auscultation.

2. Impress clearly on the memory the breathing, cough, whisper, and voice sounds of the trachea; which may be heard through the stethoscope placed over any portion of that tube; and remember that these sounds are typical of a cavity of considerable size, with walls of a certain degree of smoothness and hardness.

3. Familiarise the ear with the sounds of breathing, cough, whisper, and voice, in a bronchial tube; and especially with the distinctive characters of these compared with the vesicular and tracheal sounds. This may be done, in most healthy chests, by following with the stethoscope the course of the trachea down to its bifurcation (see fig. 6), and listening, as you proceed, to the change of sound in passing from the main tube to either of its branches; and still advancing, watch the change as the bronchus becomes imbedded more deeply in vesicular lung-substance. When you have lost the bronchial, and hear only the vesicular sounds, place the stethoscope over the back of the chest, between the scapulæ, in a line with the second and third dorsal vertebræ, where again you will recognise the bronchial sounds. (In a few healthy chests bronchial sounds cannot be heard in these regions.)

4. Particularly bear in mind why you lost the bronchial sounds, which though lost did not the less exist, but were simply inaudible at the surface of the chest, when vesicular air-containing lung-substance intervened.

Fig. 6.



Position of the lungs midway between expiration and inspiration, and the relations of the trachea and principal bronchi to the ribs and sternum.

5. Remember that healthy vesicular murmur *cannot be imitated* by anything, but must always come from healthy lung; but do not forget that as it obscures the sounds which you know are passing beneath it in the healthy bronchi, so may the sounds of disease be going on beneath it and yet be inaudible; and remember also that in its turn vesicular murmur may exist, but not be heard.

6. Remember that tracheal sounds always indicate disease when heard elsewhere than over the trachea,—that in health there is no cavity in the lung large enough to yield them after you have passed the first bone of the sternum.

7. Remember that bronchial sounds always indicate disease when *heard* elsewhere than at the two points, in which you have already found them in the healthy chest; but do not forget that they *exist* throughout the whole bronchial tree, and need only a change in the conducting medium to bring them audibly to the surface (see Conduction of Sound, p. 14).

8. Familiarise the ear with the breathing sounds through your own nose during slow, quick, and forced respiration, and with all the varieties you can produce by different degrees of compression applied to the nares; also take notice of the nasal breathing sounds when you are suffering from catarrh. For many of the sounds to be heard in the chest, due to alteration in the calibre and in the mucous lining of bronchial tubes, may be thus learned, with the advantage of being able to identify the cause of each.

Educate the ear by experiments on inanimate bodies. Take a piece of vulcanized rubber tubing, three feet long and two lines in the bore: with this a number of useful lessons may be learned. Rest about half the tube on the table or against a wall and apply a stethoscope upon it lightly; listen, while, with one end of the tube in the mouth, you inspire and expire through it alternately. The sounds heard will be something like loud bronchial breathing. Make pressure upon one portion of the tube so as to diminish its calibre at that part, and, if it is perfectly dry, *sibilant* sounds will be produced when the tube is most compressed, and sonorous snoring *rhonchus* when the calibre is only slightly diminished. By varying the extent and degree of compression, changes in the character and pitch of the breathing sounds may be produced, as numerous as those heard in the chest. It is most interesting to observe the effect of moisture in the tube, and how minute a quantity affects its sounds. If sixty drops of water are put into the three-foot tube, and the auscultation and breathing repeated as before, *large crepitation*, most abundant and loud, will appear to fill the tube for a considerable part of its length. If pressure is now made, as for the production of rhonchus and sibilus, the size of the crepitation will diminish as the calibre of the tube is decreased. If we empty the tube and blow through it to expel all the moisture possible, and again auscult it, crepitation will be heard, not of the same character as before, but more crackling, yet still distinctly bubbling; and if the tube is compressed the sounds become smaller, and assume nearly the character which they had before the water was emptied out. At parts where the tube appears dryer, loud rhonchus is heard, less musical and harsher than from the dry compressed tube. So slight an amount of moisture is sufficient to give the crepitation and rhonchus, that it is most difficult, having once moistened the tube, to get it again so dry as not to produce these sounds; so that we cannot help wondering how it is that the human air-tubes are ever free from rhonchi and crepitations, when lubricated by even their normal amount of secretion.

Take a vulcanized rubber ball, with a hole in one side, partly fill it with water, and introduce, through the hole, a tube with its extremity beneath the surface of the fluid. By listening through a stethoscope placed on the ball while we breathe through the tube, *gurgling* will be heard in the ball, varying in its character with the force of breathing, the size of the tube, and the depth of the fluid through which the air has to pass. The smaller the aperture of the tube the more the gurgling loses its distinctive characters and approaches to *crepitation*.

If a *dry* ball and tube are now taken and ausculted again during respiration, breathing sounds of cavernous character are heard. These, however, are best learned by auscultation of the trachea; but a point of interest may be noticed, viz., that the sounds of breathing and voice in the ball appear to penetrate the stethoscope much more than the same sounds traversing a large tube. This may be demonstrated by ausculting, first, the ball; then a vulcanized rubber tube, half an inch in the diameter of its bore.

The sound of *succussion* is well imitated by filling a water cushion partly with air and partly with water, and then either jolting it in such a manner as to dash the water against the wall of the cushion, or shaking it so as only to splash the water upon itself. The sound will be more gurgling in the latter than in the former case. (See p. 13.)

If a glass bell is suspended in air and then a small blast of wind suddenly directed against its margin, we may hear, first, the rush of the air, and then, following it at a distinct interval, a faint ring of the bell; the same effect is produced if the gust is directed against the interior wall of the bell. This corresponds in essential characters with the sound called *metallic tinkling*. (See pp. 12 and 24.)

If we now suspend lightly a thin glass or metal flask, so that it can ring when struck; and while listening attentively, with the ear close to, but not touching, the wall, pour some water slowly, drop by drop, into it from the neck, a dropping is heard accompanied by a slight ringing, but quite distinct from the sound of the last experiment. This dropping corresponds in essential characters with the sound called *gutta cadens*. As the water collects in the flask the dropping becomes more dead, is raised in pitch, and the ring of the flask is lost. (See pp. 12 and 24.)

The difference in character and in acoustic conditions between *tympanitic* and *amphoric* resonance on percussion may be learned by the simple experiment pointed out by me in the 'Medical Times and Gazette,' May 20th, 1858.

"Tympanitic resonance requires that the cavity percussed shall be full of air, but shall not communicate freely with external air.

"Amphoric resonance requires that the cavity percussed shall communicate freely with external air.

"That is, in the former case, the volume of air must be more or less confined; in the latter, it must not be confined at all. The simplest demonstration of this difference may be made by procuring one of the vulcanized rubber balls, now common as toys. Seal up the small hole in it and percussion will yield *tympanitic* resonance; unseal the hole, and the resonance will still be imperfectly tympanitic, the aperture being too small for free communication with the external air; cut the hole large enough that no hissing is produced by the escaping air when the ball is suddenly compressed, *i. e.*, large enough to admit of free communication with the external air, and percussion will elicit *amphoric* resonance."

The varieties of percussion sound yielded by different bodies may be learned with great advantage by percussing a waterproof cushion filled with different kinds of matter, as water, air, wool, saw-dust. We may particularly observe the change in the percussion note while the cushion is more and more distended with air. Percussion should in fact be practised upon bodies of all kinds, until the ear is perfectly familiar with the differences of each, and can identify them with the eyes shut.

The sound called *bruit de pot fêlé* may be very closely imitated by taking one of the vulcanized-rubber-balls with a small aperture in one side, already mentioned, and while it is placed upon a table, lay one finger upon it as a pleximetor, and then percuss the ball, the air from which puffs out at the hole: if a small glass or metal tube is pushed into the hole so as to project a little into the cavity of the ball, the sound of the air in escaping acquires a more metallic quality.

In this experiment we learn the acoustic conditions essential to the sound in question, viz., a space bounded by elastic compressible walls, containing air, communicating with the external atmosphere by a small orifice; it also teaches the method of percussion necessary to elicit the sound from the chest when these conditions exist, viz., "to give the impulse slowly and heavily, and allow the fingers to press forcibly on the part for some moments after it has been given."—*Walshe.*

Percussion of a vulcanized rubber foot-ball yields an admirable specimen of *metallic resonance,* and may well be added to the list of bodies upon which to practise percussion, as it also shows how a metallic sound may be yielded by bodies, under favorable circumstances, without their possessing the usual physical properties of metals. The sense of touch, as well as that of hearing, should be practised during these experiments. The detection of fluctuation by tact may be perfectly learned on the water cushion, and the elastic resistance of confined air, on the vulcanized foot-ball. All varieties of *friction-sound* may be imitated by rubbing together beneath the stethoscope different materials, such as cloth, silk, velvet, leather, both wet and dry.

Not less important knowledge is an acquaintance with the influence of conducting media upon sound, and this may be easily acquired by listening to the tick of a watch, with different materials intervening between it and the stethoscope, or by producing rhonchus or crepitations in the elastic tube, before spoken of, and listening to them in the same manner.

It would be a great mistake to suppose that these sounds, produced by experiments on inanimate bodies, are exactly like those audible in the chest; that is not pretended for a moment, although many of them are extremely similar, and convey an impression much more correct than any verbal description. The special advantage to be gained from the practice of these experiments consists in the education thus given to the ear; the acoustic conditions are in each case plainly seen; the sound can be listened to with ease, as often as requisite, free from the disturbances of the bedside; and hence, with a little perseverance, the susceptibility of the ear to distinguish and identify sounds and their causes will become so acute that the learner will be able to assign most sounds to their essential acoustic conditions, and will readily understand what he hears when he auscults or percusses the human chest.

We must not forget to guard against the danger of concentrating the attention on the special senses to the exclusion of that *common sense,* without which no learning, talents, or skill, and no accumulation of evidence, will insure wisdom in our judgments.

In an examination of the chest for the purpose of diagnosis, common sense dictates, that no opinion should be formed of the importance or meaning of any delicate modification of sound until a comparison has been instituted between corresponding portions of the two sides of the thorax: and that we should not commence by seeking for signs of any *special pathological state,* which would be to begin the inquiry at what should be its end, and must terminate in confusion and loss of time. If we remember that it is matter with which we are concerned, and that the principal physical changes of which matter is susceptible are few and simple, we shall very much curtail the examination and secure a safe basis for each step as we proceed.

Having gained the best general ideas of the nature and seat of disease which inspection, palpation, and mensuration can afford, the first question in our future inquiry will be whether any part of the chest deviates from the percussion, respiration, or voice sounds of health. If not, the examination of physical signs naturally concludes. If, on the other hand, some deviation is detected, the question becomes, what physical change has occurred to account for it. This question will be most easily and quickly answered by dividing it as follows:

Is there consolidation (or increased density)?

Is there liquefaction?

Is there excavation?

Is there roughening of surfaces that should move smoothly upon each other?

Are these surfaces removed from normal apposition?

One or all of these divisions of the question may be answered either negatively or positively. And then succeed further questions, as to the extent, amount, &c., of each of the physical changes, and as to the relations existing between any two or more of them,—questions in which may be involved all the acoustic knowledge discussed in the preceding pages.

After this manner the inquiry may be kept within definite limits, and the mind prevented from wandering into desultory observations leading to no practical result.

Having arrived, as accurately as possible, at the physical properties of the altered structure, the question as to its pathological nature may be proceeded with at once. This will require the assistance of collateral information from other sources than physical signs, and the correct answer will be most easily arrived at by a process of negative argumentation, or, as it is called by logical writers, "abscissio infiniti," that is, by excluding, one by one, suppositions as to the nature of the change, and thus bringing the inquiry within such narrow limits that it is easily decided.

In order to facilitate such an analysis as I have here suggested, the various pathological states represented in the following plates have been arranged according to their simplest and most obvious physical characters; it will be easy, therefore, to institute a comparison between the signs common to one physical change and those peculiar to the different pathological conditions by which that change is produced.

PLATE I

CONSOLIDATIONS

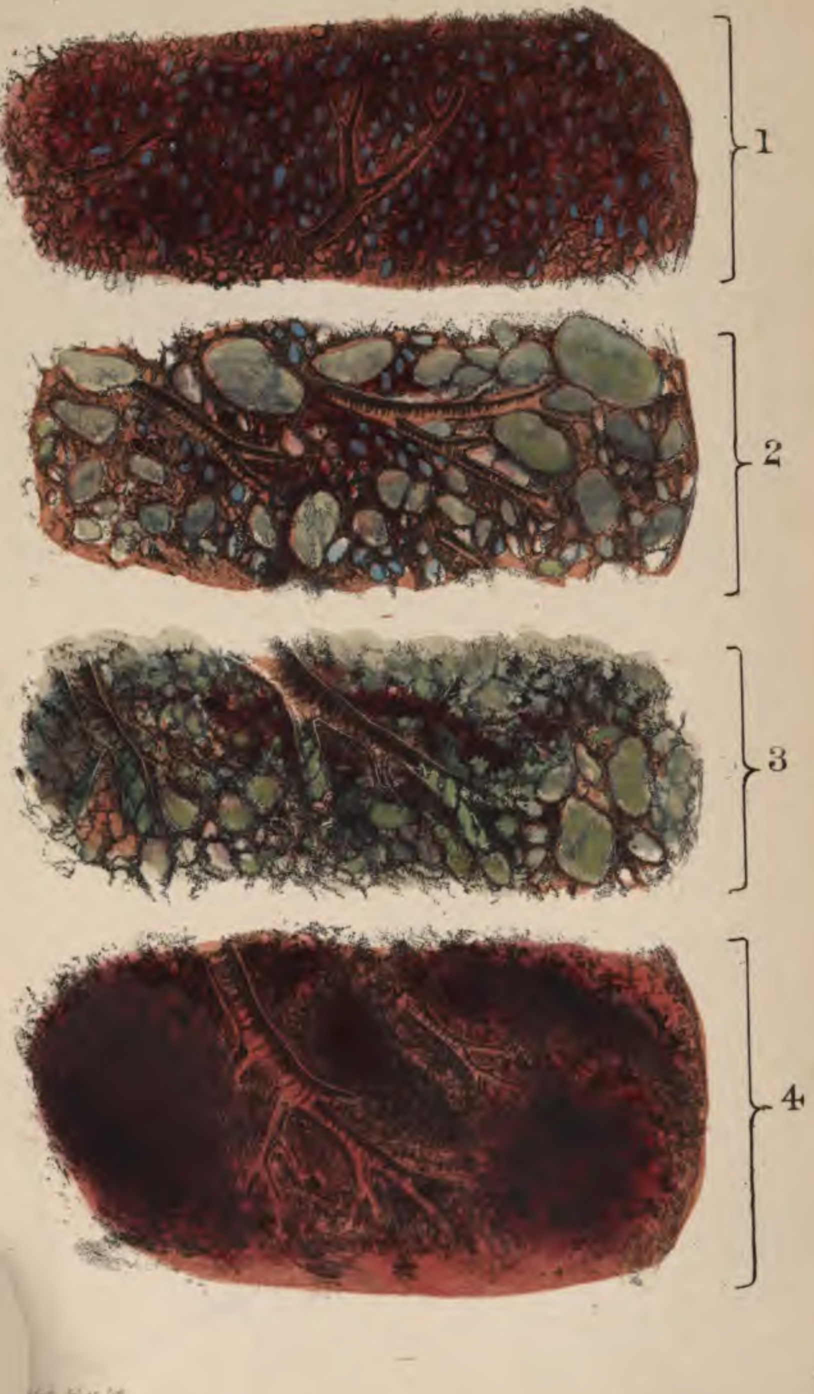


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FIGURE 1.

ISOLATED (MILIARY) INTERSTITIAL TUBERCULOUS GRANULATIONS. *Deposited outside the air-cells.*

INSPECTION, PALPATION, MENSURATION, give no constant results but the infraclavicular regions are usually flattened.

PERCUSSION normal; or slightly impaired if some tubercles are very superficial; or increased resonance, from superficial emphysema.

AUSCULTATION unsatisfactory. Respiratory sounds may be harsh; expiratory murmur usually prolonged; inspiratory murmur may be jerking; or vesicular murmur may be absent or nearly so; or co-existent bronchitis may produce rhonchus, sibilus, or crepitation of varying size. Vocal resonance gives no constant results.

COUGH may be present, or not. SPUTA, none, or colourless, frothy, watery, or [illegible]. Hæmoptysis may be present or not in varying quantities.

FIGURE 2.

CONGLOMERATED INTERSTITIAL TUBERCULOUS GRANULATIONS. *The same as fig. 1, deposited in groups; [illegible]*

EXPANSION [illegible]

PERCUSSION dull; [illegible]

AUSCULTATION [illegible]

COUGH, almost constant; [illegible] barley-water [illegible] becoming less and less [illegible]

FIGURE 3.

[illegible] *Deposited inside the air-cells [illegible]*

[illegible]

FIGURE 4.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] figs. 11, 12.

PLATE I

CONSOLIDATIONS

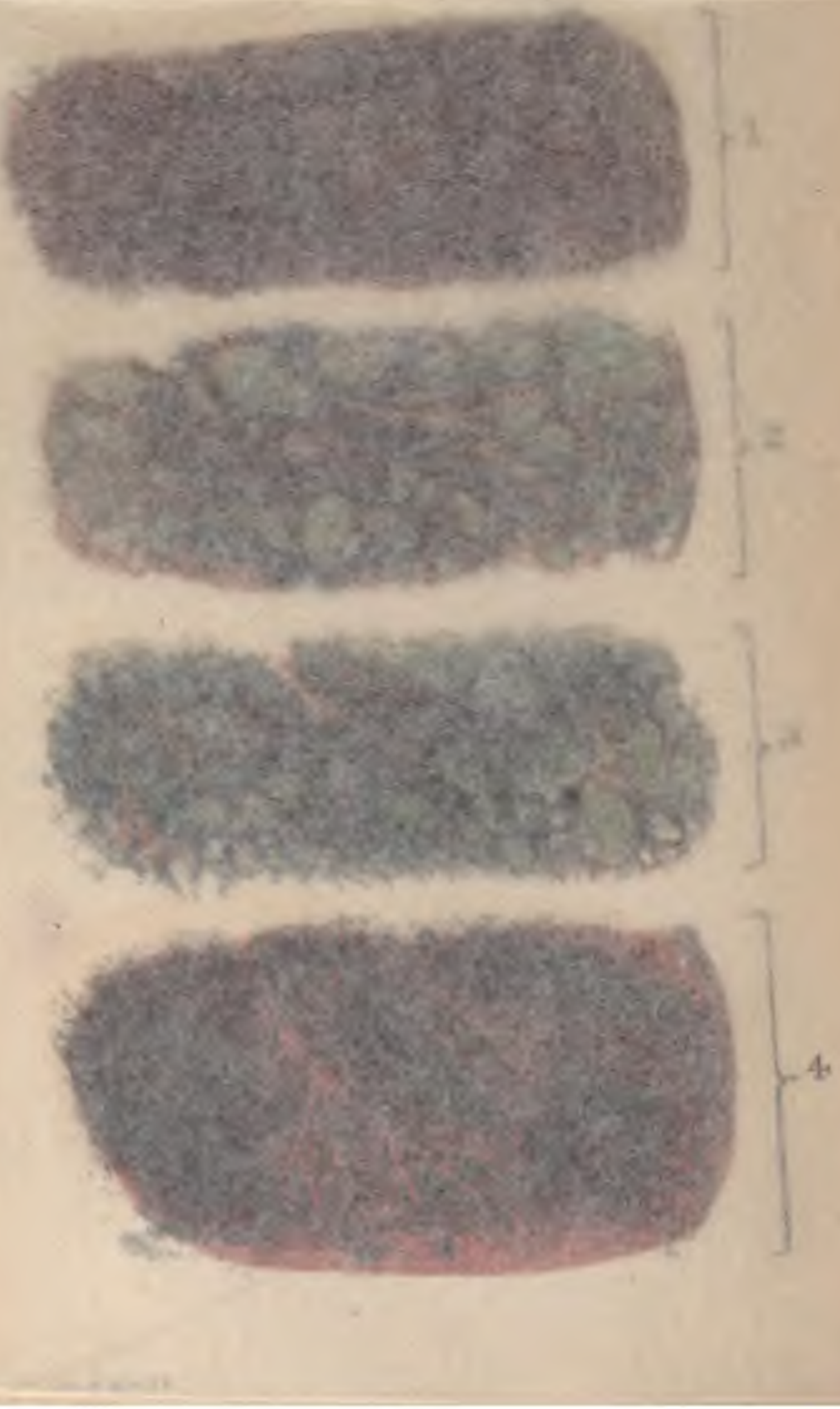


PLATE I.—CONSOLIDATIONS.

Figure 1.

Isolated (Miliary) Interstitial Tuberculous Granulations. *Deposited outside the air-cells.*

Inspection, Palpation, Mensuration, give no constant results but the infraclavicular regions are *usually* flattened.

Percussion normal; or slightly impaired if some tubercles are very superficial; or increased resonance, from superficial emphysema.

Auscultation unsatisfactory. Respiratory sounds may be harsh; expiratory murmur usually prolonged; inspiratory murmur may be jerking; or vesicular murmur may be absent or nearly so; or co-existent bronchitis may produce rhonchus, sibilus, or crepitation of varying size. Vocal resonance gives no constant results.

Cough may be present, or not. Sputa, none, or colourless, frothy, watery, or mucilaginous-looking. Hæmoptysis may be present or not in varying quantities.

Figure 2.

Conglomerated Interstitial Tuberculous Granulations, *the same as fig.* 1, *deposited in groups; involved vessels, bronchial terminations, and air-cells, obliterated by pressure. In parts—traversed by large pervious bronchi.*

Expansion diminished, chest-wall may be flattened. Vocal fremitus plus.

Percussion dull; resistance increased.

Auscultation. See fig. 1, minus—respiratory murmur, if the deposit is abundant: plus—bronchial breathing and voice, where traversed by large pervious bronchi; and conducted heart-sounds,

Cough, almost essential, rarely paroxysmal. Sputa, see fig. 1, plus—sometimes a grumous deposit from the thinner sputum, resembling that from barley-water: glairy mucus, with streaks of yellowish or buff opaque matter, becoming less and less aërated.

Figure 3.

Infiltrated Tubercle. *Deposited inside the air-cells and passages. In some places collected into groups, in others scattered.*

See fig. 2, strongly marked; plus—Sputa, more or less mixed with tuberculous matter.

Figure 4.

Apoplexy of the Lung, after coagulation. *Effusion of blood, with laceration, into the interstitial areolar tissue; without laceration, into the air-cells and passages.*

No signs from small masses, unless quite superficial. From large masses or groups of small masses, resistance plus.

Percussion, impaired or dull.

Auscultation. Respiratory murmur diminished or absent;—in the neighbouring parts harsh. Where the coagula are traversed by permeable bronchi, bronchial breathing and cough, vocal fremitus plus.

Cough varies in character with the primary disease. Sputa hæmoptic, generally darkish in colour, rarely a large quantity of blood, but tinged mucous striæ of blood, pure blood. See Pl. V, figs. 17, 18.

PLATE II.—CONSOLIDATIONS.

FIGURE 5.

HEALED CAVITIES. *Fibro-cellular cicatrices and chalky concretions.*

Chest-wall depressed.

PERCUSSION dull.

AUSCULTATION. Vesicular murmur absent. If pervious bronchi are involved, bronchial breathing and voice.

COUGH, variable. **SPUTA**, more or less, as Pl. I, figs. 1, 2, 3, plus — occasional particles, of different sizes, of cretaceous matter.

FIGURE 6.

FIRST STAGE OF PNEUMONIA ("ENGORGEMENT").

Costal movement restricted, if pleuritic pain. Vocal fremitus normal.

PERCUSSION impaired in proportion to the amount of engorgement.

AUSCULTATION. Respiratory murmur weak or suppressed in the affected parts, exaggerated in the neighbourhood and in the opposite lung. Vocal resonance somewhat increased when exudation has commenced. *Fine crepitation* on deep inspiration, especially after cough, persistent after expectoration. It may be masked by the rhonchus, sibilus, or large crepitation of bronchitis, but with care may generally be caught at the end of a deep sighing inspiration.

COUGH moderate, rarely paroxysmal. **SPUTA** sanguinolent or rusty, viscid, semi-transparent, adhesive, slightly aërated. The tint may vary,—occasionally liquorice, or prune-juice colour, or watery, brown, or blackish,—in rare cases only white and viscid,—more rarely absent.

NOTE.—ACUTE ŒDEMA OF THE LUNG presents the physical signs of fig. 6, except that the crepitation is less *fine*. **SPUTA** *not* sanguinolent, but watery or muco-purulent.

FIGURE 7.

SECOND STAGE OF PNEUMONIA ("RED HEPATISATION"), *traversed by pervious bronchi.*

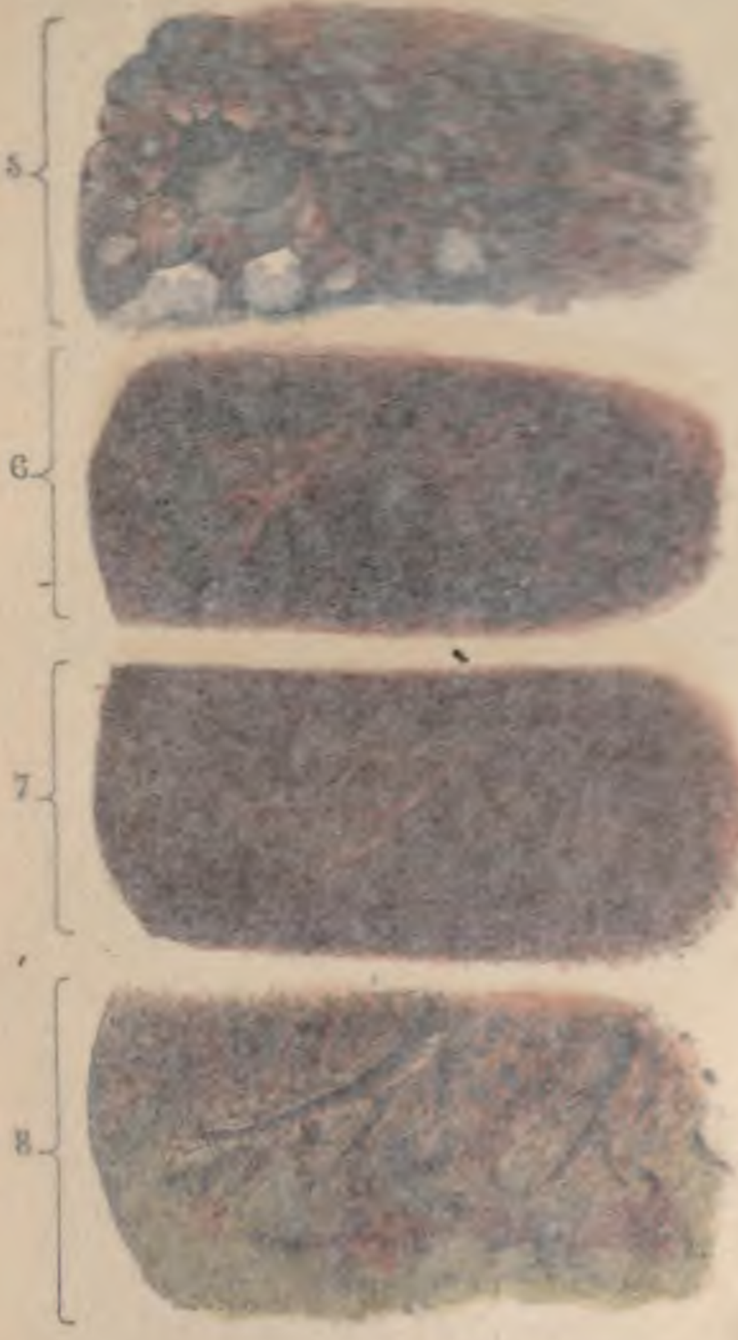
Signs of, Pl. I, fig. 2, marked; minus—flattening of the chest-wall: plus—blowing or tubular quality of respiration. In the circumference of the affected part, signs of fig. 6 may often be heard.

COUGH AND SPUTA, see fig. 6. The sputa may gradually become simply muco-purulent.

FIGURE 8.

SECOND STAGE OF PNEUMONIA, *passing into the third.*

Signs of fig. 7 passing into those of Pl. IV, fig. 15.



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CONSOLIDATIONS.

PLATE II

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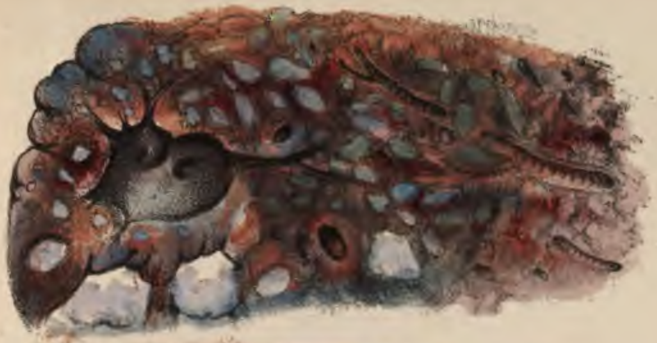

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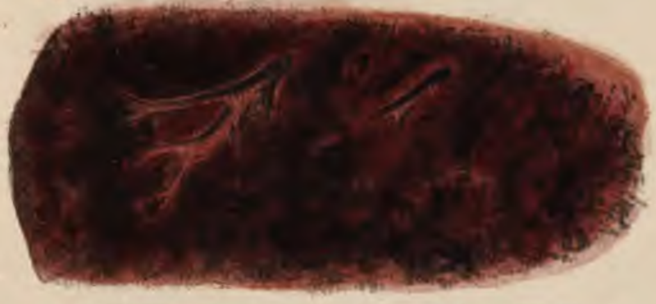

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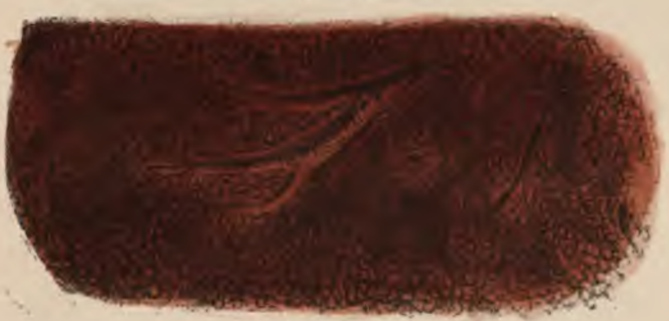

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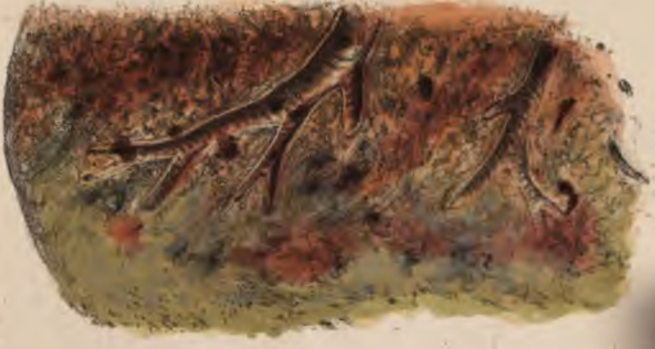

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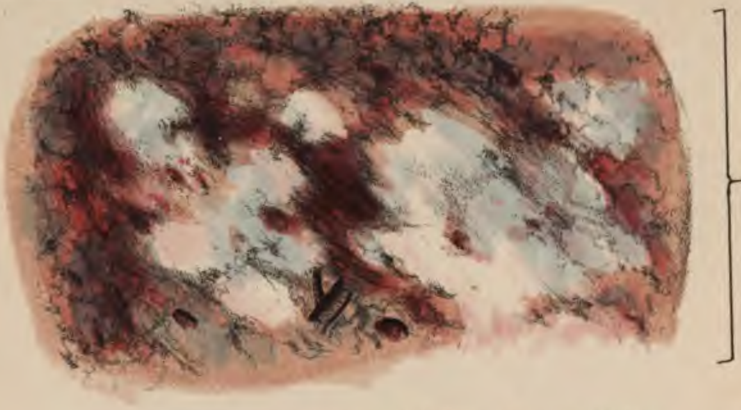
PLATE III.

CONSOLIDATIONS.



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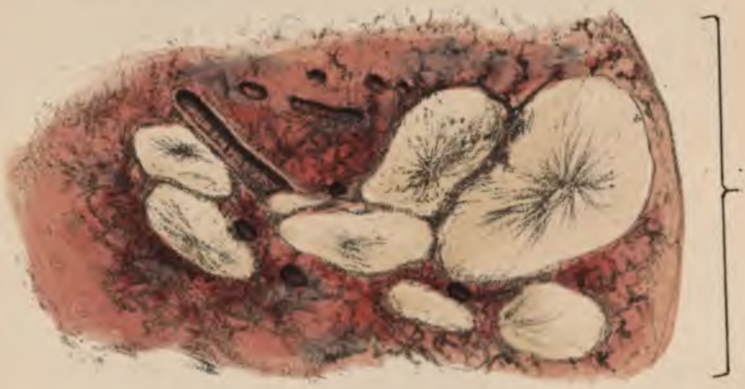

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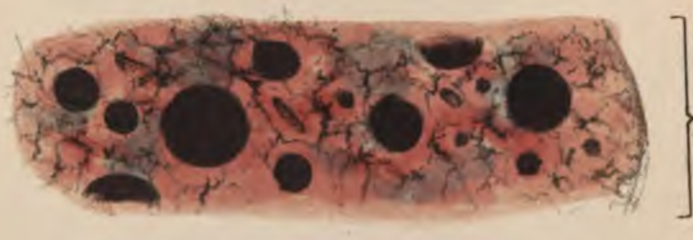

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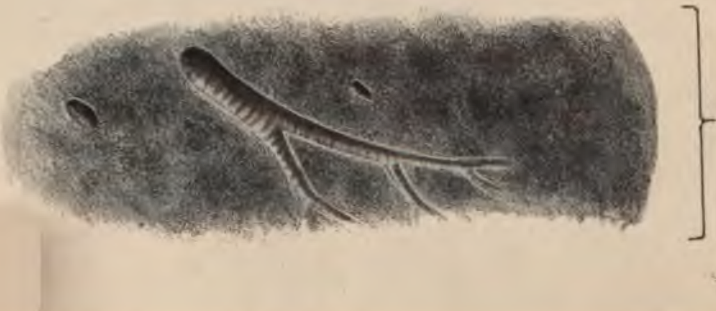

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PLATE III.—CONSOLIDATIONS.

FIGURE 9.

MEDULLARY CANCER.

Signs of Pl. I, figs. 2, 4, and of Pl. III, fig. 12, according to the extent and situation of the disease: plus—notable *flattening* of the chest-wall in infiltrated cancer; *protrusion* in actual thoracic tumour. The disease is usually limited to one lung. Dulness on percussion sometimes extending over the mesial line.

COUGH invariable, very rarely dry. SPUTA, catarrhal, purulent, often intimately mixed with blood, giving a red or black currant-jelly appearance, cancerous matter rarely mixed; free hæmoptysis frequent; fœtor of the breath occasional.

FIGURE 10.

HARD CANCER.

Signs of fig. 9.

FIGURE 11.

MELANOID CANCER.

Signs of figs. 9, 10.

FIGURE 12.

INDURATED LUNG, THE EFFECT OF PNEUMONIA, *traversed by permeable bronchi.*

Signs of Pl. II, fig. 7. Dulness and resistance especially marked.

COUGH AND SPUTA not characteristic.

CHAPTER VI.

COROLLARIES TO PLATES.

Corollary to Plates I, II, and III—Increased vocal fremitus—Impaired percussion sound—Bronchial breathing—Prolonged expiratory murmur—Jerking inspiratory murmur—Deficient vesicular murmur—Harsh respiration—Fine crepitation—Small crepitation of capillary bronchitis—Diagnosis of early phthisis, precautionary remarks.

In these plates a group of physical signs, consisting of increased vocal fremitus, impaired resonance on percussion, and bronchial breathing, recurs again and again. The acoustic principles upon which these phenomena depend for their explanation have already been discussed. (See Acoustics.)

Taken singly, they are of little value, but associated in a group, they indicate most clearly the existence of consolidated contents within the chest traversed by pervious bronchial tubes; they are the signs of a certain physical condition; but as this condition is produced by a number of different forms of disease, some additional evidence is needed in each case to give a pathological meaning to the physical diagnosis. (See p. 68.)

Some of this evidence will be found in the separate figures of the plates, but some lies beyond the reach of physical signs—in the symptoms and history of each particular case.

In Pl. I, fig. 1, the most tangible physical sign is "*prolonged expiratory murmur*" (see Rhythm, p. 29); but, as in Pl. VII, fig. 24, it accompanies cavities, it cannot be said to specify consolidation:—in Pl. IX, fig. 29, it accompanies inflamed bronchial lining, and hence it does not necessarily indicate cavity. But all three cases will be found to agree in one respect, viz., *that the exit of tidal air* from vesicular lung tissue is impeded. In one case (tubercle), this is due to increased density of the lung-substance, by which its resiliency is impaired; in the next (emphysema), to a distended condition of the air-cells, preventing the normal collapse of the lung during expiration; and, in the third (bronchitis), it is due to the diminished calibre and elasticity of the tubes through which the air has to escape.

Prolonged expiratory murmur, then, signifies impediment to the escape of breathing air. Great caution must be exercised in deciding that the normal relation between the length of the expiratory and of the inspiratory sound is permanently changed, for much depends upon the manner in which the patient breathes—the degree of volition given to the act; and I believe that no value is to be attached to slight varieties in the durations of the two respiratory sounds, unless it is quite certain that the breathing is automatic at the time of examination. This point has not, I think, been sufficiently enforced in the numerous discussions on the subject of prolonged expiratory murmur; its importance is quickly demonstrated by listening to a patient's chest when he is asleep or not attending to your operation, and again listening after giving him your best instructions how to breathe, when he will generally draw a sharp, short breath, and then expire as long as he can.

The *inspiratory murmur may be "jerking,"* that is, the sound may be produced in a divided manner, not in one soft, continuous strain. This change may take place from so many different causes, and may be absent though either of those causes exist, that it is not one to which much diagnostic value can be safely attached. If, however, the jerking inspiration is confined to the *apex of one lung,* and if it is clear that pleuritic adhesion does not exist there, the sound acquires some value as a sign of increased density of that portion of lung.

The vesicular murmur may be deficient. (See Intensity, p. 28.) Great caution is needed in concluding that the respiratory murmur is abnormally deficient, unless the change is well marked. It may be weak on both sides from general debility, or from timidity on the part of the patient during examination. A slight deficiency on the left side as compared with the right, may be observed in a large number of healthy chests; deficiency is, therefore, a more valuable sign when it occurs on the right side than on the left. (See Harsh Respiration.) Again, it must be remembered that pleuritic effusion on either side may mask the vesicular murmur, and give a false notion of its deficiency.

In Pl. I, figs. 1, 2, 3, "*Rough or Harsh Respiratory Murmur*" is noted. (See Timbre, p. 32.) It is another of those delicate changes in the quality of the respiratory sound which may or may not be valuable as a sign of early disease, according to co-existing circumstances. And the signs at this period are so few, so subtle, and so unsatisfactory, yet the information sought from them—the detection of altered structure, almost before it is altered, while disease pauses on the threshold—so eminently important, that it behoves us especially to weigh the meaning of any language in which it is told, however faint the tones. Harsh or rough respiration may be said to *grow out of prolonged expiratory murmur and to grow into bronchial breathing.* It is heard in "incipient tuberculization, dry bronchitis, vesicular emphysema, chronic pulmonary consolidation, dilatation of the bronchi, and incipient cancerous infiltration of the lung, in cases where the lungs are slightly compressed by plastic or tuberculous matter in the pleura, in the resolution stage of pneumonia, at different periods of pleurisy, and in pulmonary apoplexy." (Dr. Walshe, p. 102.)

Harsh respiration, by itself, therefore, indicates only that the vesicular structure is, from some cause or other. impeded in its equable, resilient expansion and contraction. Other signs or circumstances must be co-existent to give specific value to this change of sound as diagnostic of any particular form of disease. And as, in speaking of *deficient respiratory murmur,* caution was given to remember that the breathing sounds are often normally weaker on the left side than on the right, so must that caution be here repeated in a converse sense, lest a normal increased loudness on the right side be mistaken for harsh respiration when compared with the left. These delicate modifications of sound can be taken to mean anything, only, when every source of fallacy has been scrupulously avoided. (See remarks on diagnosis of early phthisis).

"*Fine Crepitation*" Pl. II, fig. 6.—This peculiar and delicate sound is one of the most valuable revealed by auscultation. Among all the morbid changes depicted in these plates, this figure alone presents the sign of "*Fine Crepitation.*" In its true character it is to be heard only in the first stage of pneumonia. In Pl. II, fig. 6, however, an appended note on "Acute Œdema" mentions a slight modification of this sound, which may be mistaken for it when no opportunity of comparison is afforded,—a mistake against which the auscultator must be ever on his guard. Fine crepitation is distinguished from the smallest crepitation, noted in Pls. IV and V, figs. 13, 16, 18, by its crackling character, whereas in both of those cases the crepitation is bubbling. It must be most scrupulously distinguished from the *small crepitation* of capillary bronchitis, which, I fear, is often confounded with it. There is this difference, that in fine crepitation the sound is almost always limited to the inspiratory act, and is crackling, while in the small crepitation of capillary bronchitis it accompanies both expiration and inspiration, and is bubbling. Fine crepitation, once established, is not removable by coughing or by expectoration, but remains until replaced, either by some other morbid sound, or by the happy return of normal respiratory murmur.

DIAGNOSIS OF EARLY PHTHISIS.

In association with Pl. I, fig. 1, and the corollary upon its physical signs, I venture to introduce some precautionary remarks relative to the diagnosis of Early Phthisis. It may be seen, by the plates and their explanations, that the physical signs of most serious diseases of the lungs and pleura are sufficiently marked and different to form a medium through which their changes of structure may be identified by the senses. Pneumonia, bronchitis, pleuritis, empyema, pneumothorax, have each their characteristic signs, so also, have the stages of consolidation, softening, and excavation, in tubercular disease. In its earlier progress, however, we cannot turn so satisfactorily to the results of physical examination. It is true that by this means disease may be detected in a comparatively recent state, that any *considerable* conglomeration of tubercular matter lying within acoustic reach of the surface of a lung can hardly escape detection, and that a *very abundant* deposit of isolated tubercles will, in most cases, interfere with the respiratory or other sounds of health in the chest sufficiently to give a strong suspicion of their existence. Of this, fig. 1 may be taken for an example: the miliary tubercles are extensively and abundantly scattered throughout the apex of one lung, and they did not entirely escape detection during life. But even in this case the physical signs enumerated are of a very questionable nature—neither singly nor collectively constituting an unmistakeable proof of the existence of disease. In examining such cases in private practice—impressed with their deep social import—foreseeing the shadow that will be cast over the life of the patient, the gloom of apprehensive anxiety over that of his friends, if the judgment is adverse, and, on the other hand, the bright hopes that will be reinstated if it is favorable—the physician's heart may well sink despondently within him, when he reviews the evidence from which that signal judgment must be formed.

Again and again he may hesitate to frame it; again and again he may examine and listen, in the hope of discovering some unmistakeable, some palpable signs of health or of disease; but to no purpose, for they are not there; and from a number of half-shadowed, spectral evidences, so slight and changing that their impressions can scarcely be retained while they are assembled, he must judge of the prospects of life or death.

This absence of reliable signs of the earliest stage of tubercular deposit cannot be too forcibly impressed upon the young practitioner, who, with creditable zeal, is too apt to think, and naturally prone to hope, that by sufficient diligence, experience, and care, he may insure that no tubercle shall escape his searching examination. In this belief he will be often led to fancy that he has detected the presence of tubercle where it does not exist, and to assume its absence while it really lies concealed.

This is the great disappointment which every man has to encounter who studies and practises physical diagnosis. That upon which he had set his heart—to detect the first shadow of consumption, scarcely yet resting on a life, before it is too late to drive it back—is the very dream which experience will most surely dissipate.

If physical diagnosis could detect consumption as soon as the first few spots of tuberculous matter were deposited in the lung, with the same certainty that it detects pneumonia or a cavity, we might well be content to sacrifice for this all that it could do besides. But, that it cannot, in its present state, accomplish this, and that there is no good reason to suppose that it ever will accomplish it, need surprise no one who will think calmly on the subject. It is not probable that the physical properties or the functions of a portion of lung-tissue should be sufficiently affected by a few scattered gelatiniform granules, to produce any recognisable signs of their existence. There may not be a dozen tubercles deposited in the whole lung; nay, more, there may not be one single microscopic speck deposited, and yet the disease may be working its stealthy inroads on vitality. We shall not, then, place implicit confidence in the physical diagnosis of early phthisis, but—while not neglecting this, while seeking from it all the aid it can give—we shall exert our most acute observation of symptoms, and diligently search into the histories of cases, in the hope that we may thus encounter some herald of the coming foe.

The following is an enumeration of the more delicate physical signs, by one or more of which it is presumed by different auscultators, that the deposit of tubercle may be first indicated, before the occurrence of altered resonance on percussion :

1. Prolonged expiratory sound (Jackson and others).

"I am still of opinion that an increased expiratory murmur, provided it has not a bronchial or any other character than that proper to it, indicates nothing more than this — that the air, in passing out of the lungs, meets with some obstruction in the bronchial tubes."—*Skoda.*

2. Jerking respiratory sound.

"If the other causes of jerking rhythm can be excluded, which may or may not be difficult, this condition of rhythm, when limited to one apex, becomes a really important sign of tuberculization."—*Walshe.*

3. Deficiency in the respiratory sound.

"At the apex of one lung, coexistent with puerile vesicular murmur at the apex of the other, this is at all times to be considered a suspicious condition."—*Davies.*

4. Rough or harsh respiratory sound.

"Solitary tubercles, however abundant, do not necessarily interfere with the vesicular respiration."—*Skoda.*

5. Persistent signs of bronchitis, confined to one apex.

6. Cogged-wheel rhythm of respiratory sound.

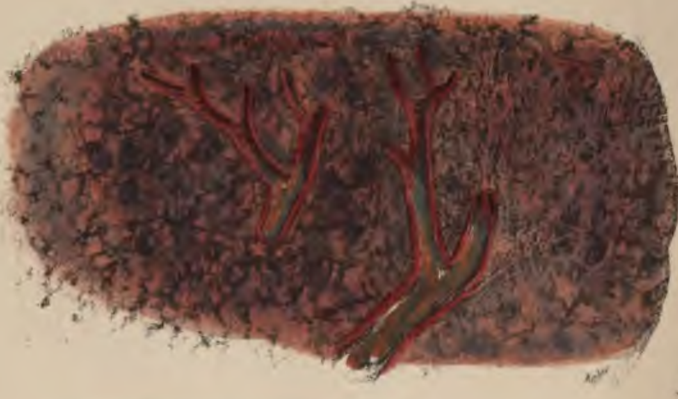
"In some cases of incipient tuberculization, the tidal air seems to struggle against minute obstructions in the finer tubes, whence a rhythm of sound resembling that of a cogged wheel in rotation."—*Walshe.*

7. "Crumpling, buzzing, humming, kettle-singing, and arrow-root-powder sounds." *Scott Alison.*

8. A variety of circumstances, the essence of which is comprised in the general terms "lessened respiratory action," with the addition of "wavy or jerking respiration and prolonged expiration." *Edward Smith.*

PLATE IV.

LIQUEFACTIONS.



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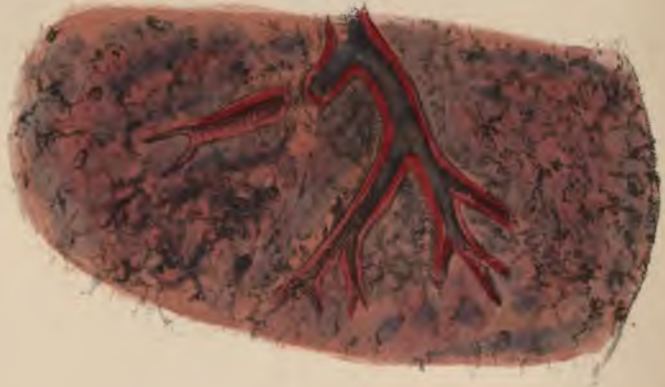

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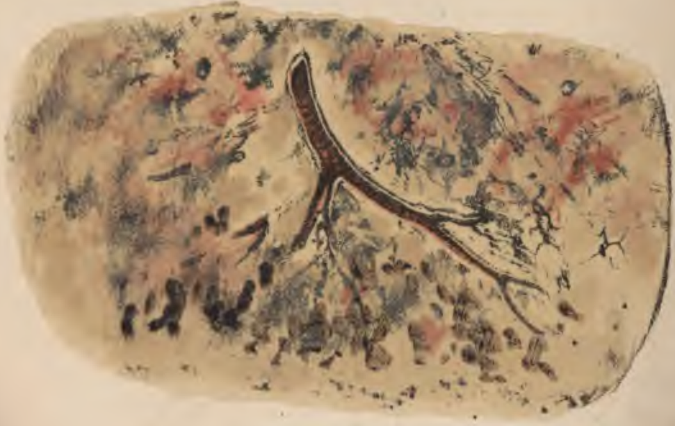

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FIGURE 13.

SECOND STAGE OF BRONCHITIS. *Exudation into the bronchi of fluid, at first viscid and frothy, afterwards more opaque and muco-purulent.*

Rhonchal fremitus occasionally felt.

PERCUSSION usually normal, but resonance may be slightly increased or slightly impaired.

AUSCULTATION. Vesicular murmur impaired. Inspiration and expiration accompanied by crepitation of various sizes, also rhonchus and sibilus. (*In capillary bronchitis the crepitation is so small that care is needed not to mistake it for true "fine crepitation"*).

COUGH loose, may be loud and hoarse, occasionally paroxysmal. SPUTA white, frothy, adhesive, becoming ropy, faint yellow, or greenish, or gray, usually running together; sometimes in pellets and opaque.

FIGURE 14.

CHRONIC BRONCHITIS. *Thickened, vascular, bronchial mucous lining, exudation of muco-serous and muco-purulent fluid.*

Expiratory movements prolonged and laboured, antero-posterior expansion plus superiorly.

PERCUSSION often slightly impaired over the lower lobes, unless emphysema coexists.

AUSCULTATION, every variety of cooing, whistling, snoring, rhonchus—mingled with large crepitation and occasional clicking and ticking sounds. Vocal resonance may be increased.

COUGH frequently suffocating and paroxysmal, varies in severity. SPUTA usually copious, of nauseous odour, in large masses little or not at all aërated; yellowish, greenish, ash-coloured, or grayish green—occasionally streaked with blood; sometimes scanty and adhesive, and sometimes (bronchorrhœa), copious watery, glairy fluid follows each paroxysm of cough.

FIGURE 15.

THIRD STAGE OF PNEUMONIA. *Purulent infiltration replacing the plastic lymph of the Second Stage,* Pl. II, fig. 7.

For Signs see Pl. II, fig. 7 (Second Stage of Pneumonia), plus—crepitation of different sizes when the suppurating tissue communicates with bronchial tubes.

PLATE V.—LIQUEFACTIONS.

FIGURE 16.

SECOND STAGE OF TUBERCULOUS DISEASE. *Reduction of the tuberculous matter and involved lung-tissues to the consistence of pus.*

For Signs see Pl. I, figs. 1 and 2, plus—increased depression of the chest-wall, and crepitation of various sizes, at first very small.

COUGH essential, troublesome, often provoking vomiting. SPUTA, see Pl. I, fig. 3, plus—purulent non-aërated pellets, and often abundant muco-purulent matter mixed with bronchial mucus.

FIGURE 17.

APOPLECTIC COAGULA IN THE LUNG, SOFTENING.

For Signs see Pl. V. fig. 18, plus—bronchial breathing and voice from the yet unsoftened portions, if they involve permeable bronchi.

COUGH not characteristic. SPUTA, sooty or bistre-coloured blood, mixed with mucus, or muco-purulent matter.

FIGURE 18.

APOPLEXY OF THE LUNG BEFORE COAGULATION, *with and without laceration of tissue. Effusion of blood into the air-cells and passages, also into the interstitial areolar tissue.*

a. SMALL EXUDATIONS, may present no signs, or crepitation only.

b. LARGE EXUDATIONS. Vocal fremitus increased, if permeable bronchi are involved.

PERCUSSION impaired or dull, according to the amount and superficialness of the effusion.

AUSCULTATION. Crepitation of all sizes.

COUGH varies with the primary disease. SPUTA, tinged mucus, or finely aërated florid blood mixed with mucus. Sometimes profuse discharge of florid blood, more or less aërated.

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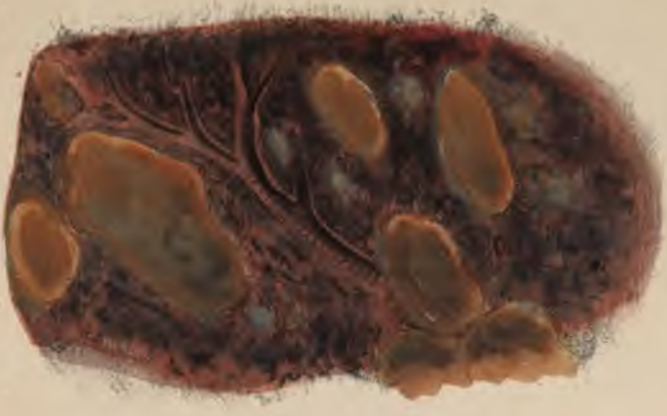

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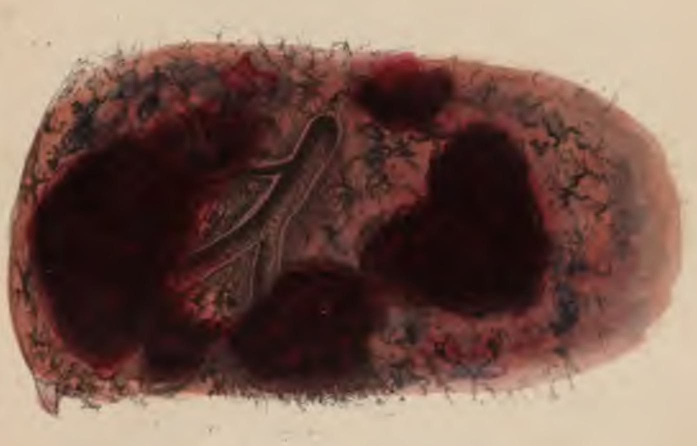

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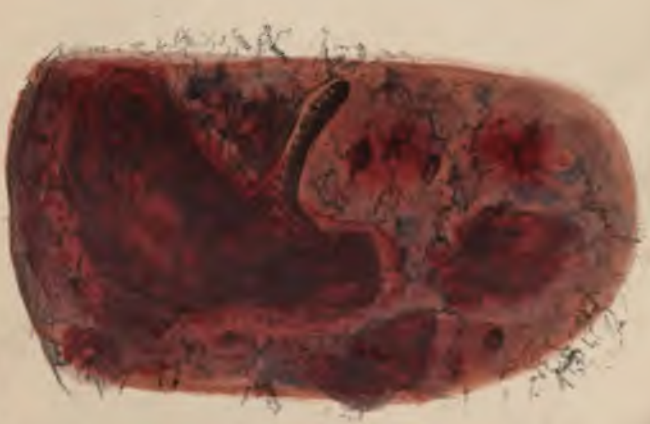

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COROLLARY TO PLATES IV AND V.

Crepitation — its meaning and acoustic conditions—Coetaneous signs—Prolonged and laboured expiratory movements.

In these plates a certain physical sign prevails, and is characteristic of the physical condition into which the different forms of disease have passed, some deposit or tissue has become liquefied, or some secretion has been poured out and mixed with air. "*Crepitation*" is present in every figure of the plates, although varying considerably in its characters, and heard in conjunction with several different sounds, which in either case may give to it a special meaning.

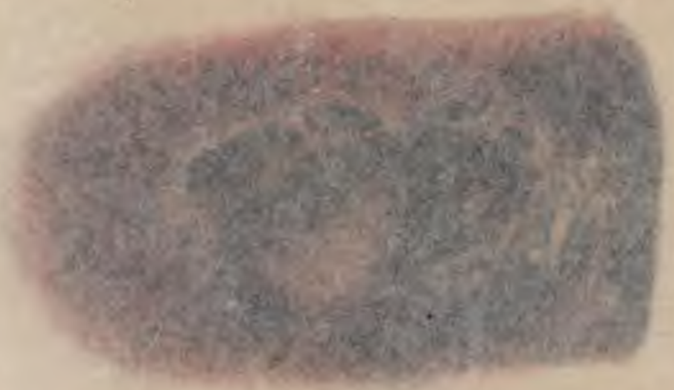
In Pl. V, fig. 18 *a*, crepitation stands alone, everything else is consistent with health, but a portion of fluid blood has found its way into the air-passages, and as the air of respiration passes backwards and forwards, bubbles are necessarily produced in the fluid through which it is pressed. That these bubbles will vary in size with that of the passages in which they are produced, and with the size of the aperture from which the air issues as it is forced through the fluid, may be easily demonstrated (see p. 62). When, therefore, we hear a number of very small bursting bubbles, or "crepitations," accompanying an expiratory act, it tells us that the air is issuing from the fine passages or cells of the lungs in a number of minute streams, and that by these some fluid is encountered before they have united into a blast of larger size; and as the air must be introduced through the same tubes before it can be expelled, the crepitation of inspiration needs no further explanation; hence, this sound—small crepitation—speaks unmistakably of fluid in the remote ramifications of respiratory tubes. If, on the other hand, the crepitations are of larger size, they tell that they must have larger spaces to contain them, and that the stream of air which produced them had a certain calibre. This is the interpretation of crepitation of various sizes, rising from the exceedingly delicate bubbling, almost like effervesence, of capillary bronchitis (Note to Pl. IV, fig. 13), to large noisy crepitation, and thence even to "gurgling" (Pl. VI, fig. 20.) Once understanding the acoustic conditions of crepitation, it will be evident that it is not necessary for the air or fluid to be confined in the respiratory tubes:—that a portion of lung-substance, broken down in structure and converted into a soft semi-fluid mass, if freely communicating with pervious respiratory tubes, may have the air from these passages forced through it, and thus yield crepitation similar to that from fluid in the tubes themselves. Thus in Pl. V, fig. 16, crepitation is yielded by masses of tuberculous deposit lying in the course of the air-passages, and reduced with the involved lung-substance to a fluid condition; while in Pl. IV, fig. 13, crepitation is due to inflammatory exudation into the air-passages themselves. Crepitation then, both large and small, indicates the presence of fluid, and the passage of air through it, but for its special pathological meaning in any given case we must look to the signs and circumstances which bear it company.

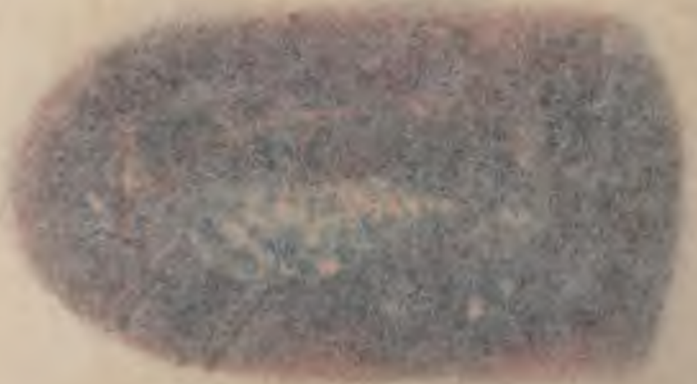
"*Impaired resonance on percussion*" *and* "*bronchial sounds*," are present in Plates IV and V, figs. 15, 16, 17, and have the same meaning as in Plates I and II:—they speak of the physical condition which preceded the conversion into fluid, and which still remains in the vicinity of the liquefied structures.

In figs. 13 and 14, on the other hand, the resonance is normal, or nearly so, and no bronchial sounds are conveyed to the surface of the chest; at once marking a most important difference in the conditions accompanying the crepitation in these and in the other figures, viz., the existence in the one case, the absence in the other, of air-containing, vesicular lung-substance.

In Pl. IV, fig. 14, "*the expiratory movements are prolonged and laboured;*" here we find a rough and exaggerated illustration of the causes of prolonged expiratory murmur, spoken of in its most delicate form in corollary to Pl. I, fig. 1. The physical cause is the same in each instance, viz., *impediment to the exit of tidal air from the vesicular structure.* But in the present case (fig. 14) this impediment exists in the conditions which give rise to the accompanying auscultatory sounds—to the cooing, whistling, snoring, piping, bubbling, there described—viz., the walls of the respiratory tubes are thickened in parts, and thus irregularly diminished in calibre, and they are partially blocked up with unhealthy secretions of various degrees of fluidity. The air, in its exit from the vesicular structure, is thus encountered by a number of oppositions, which the resiliency of the lung and the elasticity of the chest-wall are insufficient to overcome; automatic breathing is no longer competent to the task, and the necessity arises for a voluntary muscular effort to force the air through the passages: an effort which, in severe cases, complicated with emphysema (Pl. VII, fig. 24), occupies more and more the attention of the sufferer, until it becomes the engrossing business of his tedious life.

PLATE [illegible] ULCERATIONS





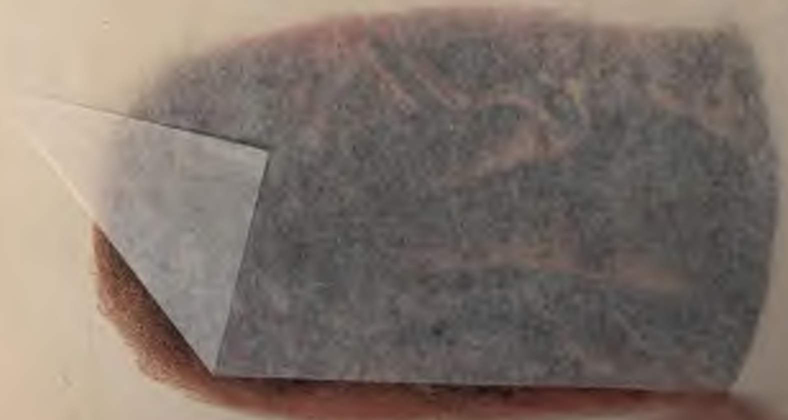


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PLATE VI.—EXCAVATIONS.

FIGURE 19.

A LARGE EMPTY TUBERCULOUS CAVITY, *with smooth reflecting walls, and free bronchial communication. The surrounding lung consolidated with tubercle.*

Chest-wall depressed; expansion diminished. Vocal fremitus marked.
PERCUSSION dull.
AUSCULTATION. Respiration, voice, and cough, cavernous. If the walls of the cavity are very dense and thin, the *lung immediately encompassing* them not consolidated, there may be *metallic tinkling*, or *amphoric echo*, on sudden, forcible inspiration, cough, or voice.
COUGH varies, generally hollow. SPUTA, none from the cavity, but from surrounding lung may be of various characters.

FIGURE 20.

A CAVITY SIMILAR TO FIGURE 19, BUT CONTAINING SECRETION.

For Signs see Pl. VI, fig. 19, plus—gurgling and large crepitation, the vibration of which may sometimes be felt on the chest-wall.
COUGH, troublesome, only relieved by expectoration. SPUTA. Pellets with sharp irregular outlines, or larger masses with flocculent edges, of yellowish colour; or broad, flat, non-aërated lumps, smooth, greenish, remaining distinct; or ash-coloured pure pus not remaining distinct, sometimes discharged suddenly and profusely. Any of these may be mixed with blood.

FIGURE 21.

A VERY SUPERFICIAL TUBERCULOUS CAVITY FULL OF AIR, *free bronchial communication, the thin stratum of super-imposed lung consolidated.*

The chest-wall occasionally bulges over the cavity. Vocal fremitus marked.
PERCUSSION clear and tympanitic, may be metallic, and if the bronchial communication is large and free it may be amphoric. *Bruit de pot fêlé* may sometimes be produced if the cavernous wall is elastic.
AUSCULTATION. If no secretion, Pl. VI, fig. 19, marked; if secretion Pl. VI, fig. 20, marked.

PLATE VII.—EXCAVATIONS.

FIGURE 22.

SMALL TUBERCULOUS CAVITIES, *bronchial communication very imperfect, super-imposed stratum of lung normal, surrounding bronchi inflamed, containing secretion.*

Chest expansion may be normal. Vocal fremitus normal.

GENTLE PERCUSSION, normal. STRONG PERCUSSION may yield more or less dullness.

AUSCULTATION. Bronchial respiration absent, or imperfect, or occasional large crepitation, rhonchus, and sibilus from surrounding bronchi.

COUGH, dependent principally on the bronchitis. SPUTA differ with the amount of bronchial communication with the cavity, &c.

FIGURE 23.

A VERY LARGE TUBERCULOUS CAVITY, *with a thick stratum of densely consolidated lung super-imposed, free bronchial communication.*

PERCUSSION, weakly tympanitic if forcible, quite dull if gentle.

AUSCULTATION. Respiration, voice, and cough, cavernous. If the cavity contains secretion—gurgling.

FIGURE 24.

EMPHYSEMA. *Enlarged air-cells, with attenuated anæmic walls: in some places the contiguous cells have coalesced.*

Chest-wall elastic, more or less *rounded,* especially in front and superiorly. Vocal fremitus variable.

PERCUSSION morbidly clear, sometimes tympanitic, unaltered by respiration.

AUSCULTATION. Expiratory sound peculiarly long and laboured; but it may be weak, inaudible, or masked by rhonchus and sibilus. Inspiratory sound short and weak, or it may be inaudible or masked.

In extensive emphysema, the heart-sounds are displaced and the area of pulmonary resonance extends beyond its normal limits.

DYSPNŒA constant, subject to paroxysmal aggravation.

COUGH not constant, but usual, paroxysmal, and suffocative. SPUTA frothy, liquid, mucous; often accompanied with the sputa of bronchitis. Pl. IV. fig. 13, 14.

EXCAVATIONS

PLATE VII

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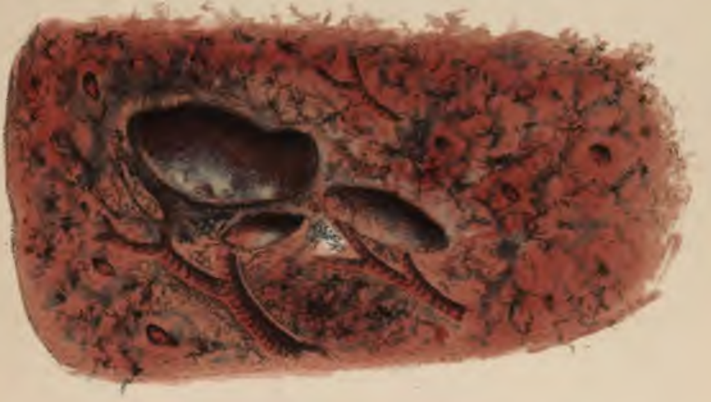

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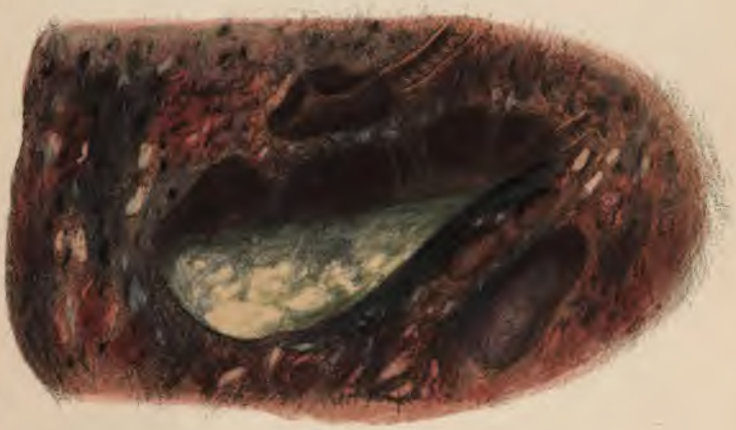

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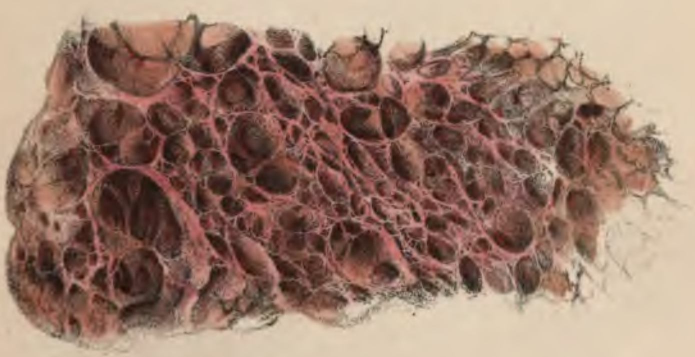

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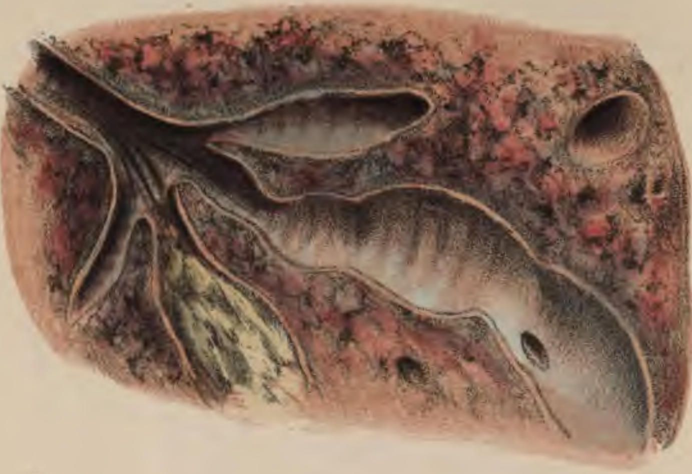
PLATE VIII. EXCAVATIONS.



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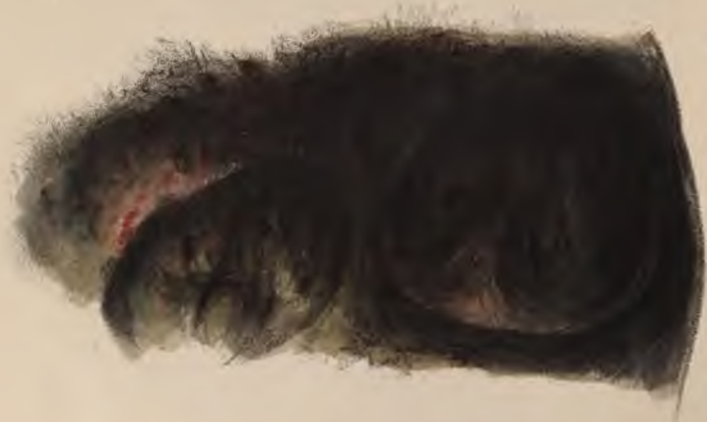

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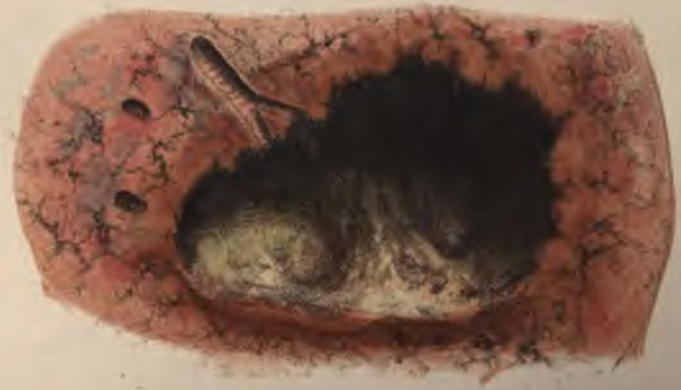

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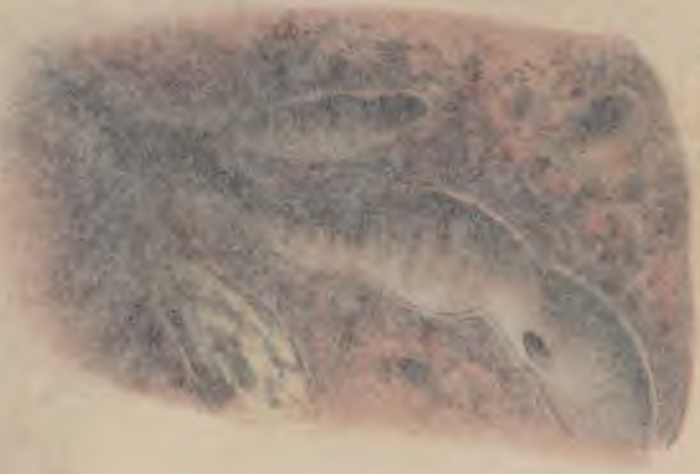

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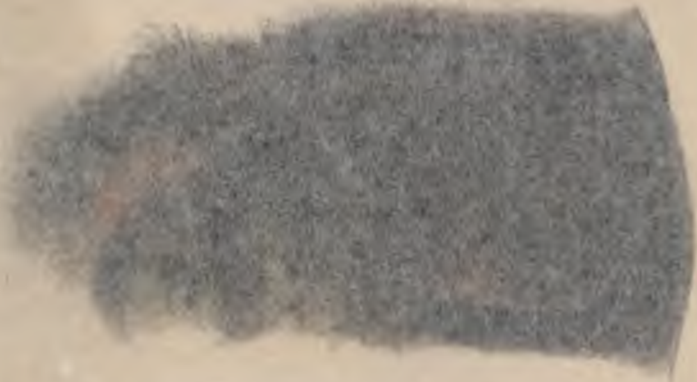

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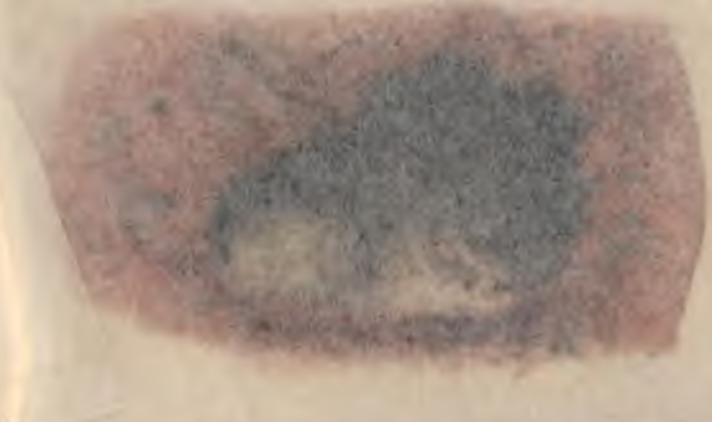

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PLATE VIII.—EXCAVATIONS.

FIGURE 25.

BRONCHIECTASIS. *Bronchi dilated, cylindrical, flask-shaped, sacculated, &c., containing secretion. Surrounding lung condensed by pressure, in the immediate neighbourhood of the tubes.*

For Signs see those of Tuberculous Cavities of different sizes and positions. Moist sounds abound, and rhonchus and sibilus are generally associated.

COUGH, essential, generally very troublesome and paroxysmal. SPUTA, Pl. VI, fig. 20, copious and opaque, odour usually nauseous; also Pl. IV, fig. 14. There is seldom much blood.

FIGURE 26.

A GANGRENOUS CAVITY.

PERCUSSION dull.

AUSCULTATION. Gurgling and large crepitation, the vibrations of which may sometimes be felt on the chest-wall.

COUGH variable. SPUTA *horribly fetid*, dirty greenish, brownish, or ash gray, very liquid, mixed with portions of disintegrated lung-tissue.

FIGURE 27.

PNEUMONIC ABSCESS. *The purulent contents more or less evacuated —remains of hepatisation in the surrounding lung.*

For Signs see Pl. VI, fig. 20, and Pl. VII, fig. 23, according to the position and size of the cavity, minus—metallic sounds. If evacuation of the contents is prevented by absence of bronchial communication, see Signs of Pl. II, fig. 7.

COUGH varies. SPUTA purulent, or muco-purulent, sometimes contain degenerated lung-tissue; may be fetid.

COROLLARY TO PLATES VI, VII, VIII.—EXCAVATIONS.

Diminished chest-expansion—Vocal fremitus—Percussion sounds, dull, clear, tympanitic, metallic, normal—Cavernous sounds, conditions rendering them important—Absence of cavernous sounds no proof of absence of cavity—Gurgling, if of pure character, ranks in importance with "metallic tinkling" and "amphoric echo"—Diagnosis of a cavity by considering signs in a group—Signs of emphysema discussed—Bronchiectasis, caution against mistakes in its diagnosis—"Bruit de pot fêlé."

Plates VI, VII, and VIII illustrate the principal forms and conditions under which excavations may exist in the lungs; and show to what extent they are indicated by physical signs during life. In fig. 19 "*the expansion of the chest-wall is diminished*" in proportion to the extent to which the lung around the cavity is deprived of its respiratory function. Whenever, and by whatever cause, a considerable portion of lung has been deprived of its expansile function, it necessarily incurs diminished expansion of that portion of the chest-wall with which it is in contact. Therefore the existence of a cavity is frequently attended by this sign, as in fig. 19: but a cavity may be too far off from the wall to affect its movements, and the intervening lung may be so little affected by disease, that the expansibility remains natural, as in fig. 22. Hence, altered expansion, although a common attendant, is not a necessary sign of excavation.

The same remark applies to "*vocal fremitus*," or the vibrations of the lung transmitted through the chest-wall. Thus, it is increased in fig. 19, because the cavity is large and contains a considerable volume of air susceptible of vibration, while the surrounding lung is rendered a good conductor by consolidation; it is marked in fig. 21, because the cavity is superficial, and the vibrations of its parietes are therefore readily impressed upon the walls of the chest; whereas in fig. 22 the vocal fremitus is little, if at all, increased.

In fig. 19 the "*percussion is dull;*"—but this is not a timbre derived from the excavation, it is due to the increased density of the intervening lung, which might exist without the cavity (as in Plates I, II, III). In fig. 21, from the superficial position of the cavity, the percussion sound is derived more directly from it, and its timbre is "*clear, and tympanitic, or metallic*" characters to be expected from percussion of air contained within thin vibratile walls. (See pp. 11, 64, 65). Again, in fig. 23, the cavity is so large in proportion to the intervening lung-substance, and this is so dense from consolidation, that when percussed with moderate force, instead of yielding the dull sound which would be proper to itself, and which is elicited by very slight percussion, it acts as a vibratile lamina to the air-containing cavity beneath, and gives out a "*weak tympanitic resonance.*"

And in fig. 22, the cavities being small, and the superimposed lung healthy, the resonance of the normal structure may be uninfluenced by the cavities.

Altered percussion sound, therefore—like diminished expansion of the chest-wall, and increased vocal fremitus—is not an essential sign of cavity.

Auscultation in fig. 19, gives "*cavernous respiration, voice, and cough*" (see pp. 59, 63), sounds characteristic of a space of *considerable size*, with walls sufficiently hard and smooth to reflect sound—of such a space in fact as the tracheal tube. These very important sounds accompany fig. 23, and may be present in the larger dilatations of fig.

25, and in figs. 20, 26, 27, provided the cavities are not too much filled with their fluid contents, or cut off from free communication with pervious air-tubes, and if the walls of figs. 26 and 27 are not too soft to reflect sound. These cavernous or tracheal sounds derive their value, in a diagnostic sense, from the following circumstances :

1. There is no part of the chest-wall, after passing the first bone of the sternum, from which they can be detected, in a state of perfect health—that is, if auscultation is properly performed; for in listening above the clavicles, if the stethoscope is carelessly directed towards the trachea, instead of in a line with the perpendicular axis of the chest, tracheal sounds may be heard.

2. Although the sounds of bronchial tubes may become audible at the surface of the chest, through increased conducting power of the structures interposed; these tubes are not large enough in health, except perhaps at their bifurcation, to give sounds like those from the trachea.

3. Cavernous sounds are produced under conditions which almost insure their reaching the thoracic parietes: viz., (*a*) a cavity so large that the vibrations of a considerable volume of air may be transmitted to its walls; (*b*) these walls must present a large surface from which vibrations may be conducted to the ear; (*c*) the walls must be of a certain density, which implies, almost of necessity, increased density of the surrounding structures—that is, increased power of conducting sound; (*d*) a cavity so large and so defined, that it will, almost necessarily, communicate freely with some of the bronchial passages upon which it has intruded, thus acquiring free ingress and egress of air during respiration, speaking, or coughing.

Hence the sounds which in health are audible only on ausculting the trachea, when heard at any part of the chest except over the trachea and its bifurcation, positively indicate the existence, not only of a cavity, but of a cavity larger than is consistent with health; and thus they have acquired the name *par excellence* of "cavernous"—as distinguished from "bronchial," from which they are separated by difference of size. Nevertheless, on turning to fig. 22, we find cavities, the result of disease, large enough to be of serious consequence, and yet no cavernous sounds are produced by them. Therefore, we learn that, although these sounds are positive evidence of the existence of a cavity, their absence is not positive evidence that no cavity exists; they thus lose much of their value; for in truth it is just in those cases in which they are not audible, that it is most important to detect the existence of disease—cases in which the general symptoms are not very marked, and which are not too far advanced to afford a reasonable prospect of recovery. (See Corollary to Plates I, II, III, fig. 1.)

The "*metallic tinkling*," and "*amphoric echo*," mentioned in fig. 19, are discussed in Corollary to Plates IX, and X, and at pp. 12, 24, 63.

Fig. 20 presents a sound which may be at any time added to the signs of fig. 19, viz., "*gurgling*" (see Corollary to Plates IV and V; pp. 13, 62). Gurgling may be produced in the largest bronchial tubes, but it then retains more of the characters of large crepitation; it has not those peculiar characteristics which gurgling acquires in cavities of larger size:—they convey to the mind a definite impression of a considerable volume of air passing through fluid, and of that fluid leaping up into an atmosphere in which the sounds it prduces are reflected from the surrounding walls.

As a sign of the existence of a large cavity containing both air and fluid, this description of gurgling takes rank with metallic tinkling and amphoric echo, as a sign of a large cavity containing air. When audible, all these phenomena are of the greatest importance.

In fig. 22, not any one of the sounds, if taken alone, is indicative of the existence of a diseased excavation; and yet such a cavity is there.—The percussion sound is consistent with health. Auscultation gives large crepitation, which may proceed, at any time, from secretion in a large air-passage. The respiratory and voice sounds are such as may be heard from a healthy, large, bronchial tube, if the superimposed lung is increased in conducting power by density.—The diagnosis turns, therefore, upon the question, whether such increased density exists to account for the respiratory and voice sounds. As the percussion sound is normal, this question is answered in the negative; and we are led to inquire how, and why, the voice and breathing sounds reach the surface of the chest in abnormal intensity and volume? The answer is either, that these sounds have acquired, by reverberation in a cavity of abnormal size, sufficient loudness to be audible through the imperfectly conducting medium of healthy lung, or that a cavity, the size of a large bronchial tube, exists nearer the surface of the lung than is consistent with normal structure. Thus do we arrive at the diagnostic meaning of the physical signs: and we may take this result as a lesson which cannot be too often repeated, viz., that physical signs must be regarded in groups, not isolated; andmust be cautiously weighed against each other before they can acquire a definite diagnostic meaning.

In fig. 24, although the whole lung-substance is seen to be converted into a labyrinth of cavities from distension and coalescence of the air-cells, we do not find any of those physical signs present which in the other figures have indicated the existence of excavations. Some such sounds, however, may occasionally be heard when a group of air-cells has been broken down into a large cavity near the surface of the lung. The "*feeble or masked respiratory sounds,*" in the present instance, might lead to the idea of obstructed and consolidated lung, did we not miss the bronchial sounds which should in that case be transmitted through it. The prolonged expiratory sound accompanied by rhonchus and sibilus in the surrounding parts, with feeble or deficient inspiratory murmur, are signs very similar to those of Pl. I, fig. 1,—and as in that case the percussion sound might be increased in resonance by superficial emphysema, the likeness is made more complete.

Nevertheless, it is hardly possible for a careful auscultator to mistake the meaning of the signs in fig. 24, when regarded in a group. In the first place, "*the resonance is morbidly clear,*" which negatives the idea of consolidation, and it is diffused over a considerable extent, whereas in the superficial emphysema accompanying early tuberculous disease (Pl. I, fig. 1), it is limited to a small space.

In the next place, the *expiratory sound is more prolonged than in any other form of disease,* and when caused by emphysema as far advanced as in fig. 24, is so marked that it cannot possibly be mistaken. It is quite true, however, that in the early stage of emphysema there may be only a slight increase in the proportional length of the expiratory sound—an increase not greater than may take place in the early stage of tubercle—and if accompanied by no other signs, the diagnostic meaning may for a time remain doubtful. But it will generally be found that an amount of tuberculous disease capable of prolonging the expiratory sound as much as it is prolonged by early emphysema, is accompanied by a history and general symptoms sufficiently marked to assist the diagnosis.

Lastly, "*the expanded chest*" of emphysema, marked especially in its upper parts, contrasts unmistakeably with the depression of tuberculous disease, when change of structure has, in either case, advanced beyond its first stage; and in aggravated cases, such as that figured in the plate, the liver, heart, or both, will be more or less displaced. Emphysema is so commonly associated with chronic bronchitis, that the signs of both may be studied together with advantage. Each aggravates the other, and they thus combine in producing the deplorable result described in Corollary to Plates IV and V.

Fig. 25 may present the most puzzling physical signs of any disease in the chest. Signs which will often lead the physician to doubt on a second visit all the conclusions he had arrived at on a first examination, and again on a third visit to hesitate between the results of the other two. A bronchial tube may be so much dilated as to yield all varieties of cavernous sounds. It may have encroached so far towards the surface of the lung, that percussion elicits sounds of clear or almost amphoric resonance. It may have so condensed the surrounding vesicular structure by pressure, that the resonance is impaired or lost, and the sounds of neighbouring parts conducted to the chest-wall. It may be choked with secretion, giving all the moist sounds of chronic bronchitis. It may be dilated in one portion, but in another reduced in calibre, producing rhonchi of varying pitch and timbre. Several tubes may be affected, and one may assume one of the forms described, and one another. The difficulties of this complication in the physical signs may be increased by the general symptoms, which may simulate those of phthisis, of chronic bronchitis, of emphysema: and either of these diseases may actually coexist with the bronchiectasis. The only hope of forming a safe diagnosis lies in a careful inquiry into the history of the case, carried back as far as possible, and an examination of the whole chest, the signs of one portion being compared with those of another: if the examination can be repeated at intervals, and the case watched for some time, its nature will generally become more and more clear. Fortunately this state of disease is not very common, but we should always be on the watch for it, to guard against mistaking it for some other form of excavation.

In connexion with fig. 21, it is mentioned that this "superficial cavity communicating with pervious bronchi," may sometimes yield a sound termed "*bruit de pot fêlé,*" about which a few remarks are required. This sound has, in truth, very little resemblance to that of "un pot fêlé,"—although it is a little more like it at some times than at others. The acoustic conditions essential to its production are described at p. 65, and in order to establish them, the patient must open his mouth while his chest is percussed, so that no impediment may exist to the sudden exit of air through the respiratory tubes. If the walls of the cavity are simply hard and leathery, however elastic, no metallic timbre is given to the sound, but rather a hissing noise; if they are more dense and vibratile, the air impinging on the borders of the aperture by which the cavity communicates with a bronchus, may produce a sound having more of a cracked-metal or cracked-pot character. But he who waits until he hears a noise realising the idea of a cracked pot, will be long before he identifies the "bruit de pot fêlé;" whereas, if he simply bears in mind its acoustic conditions, the sound will catch his ear the first time he meets with it.

PLATE IX

PLEURITIS &c.

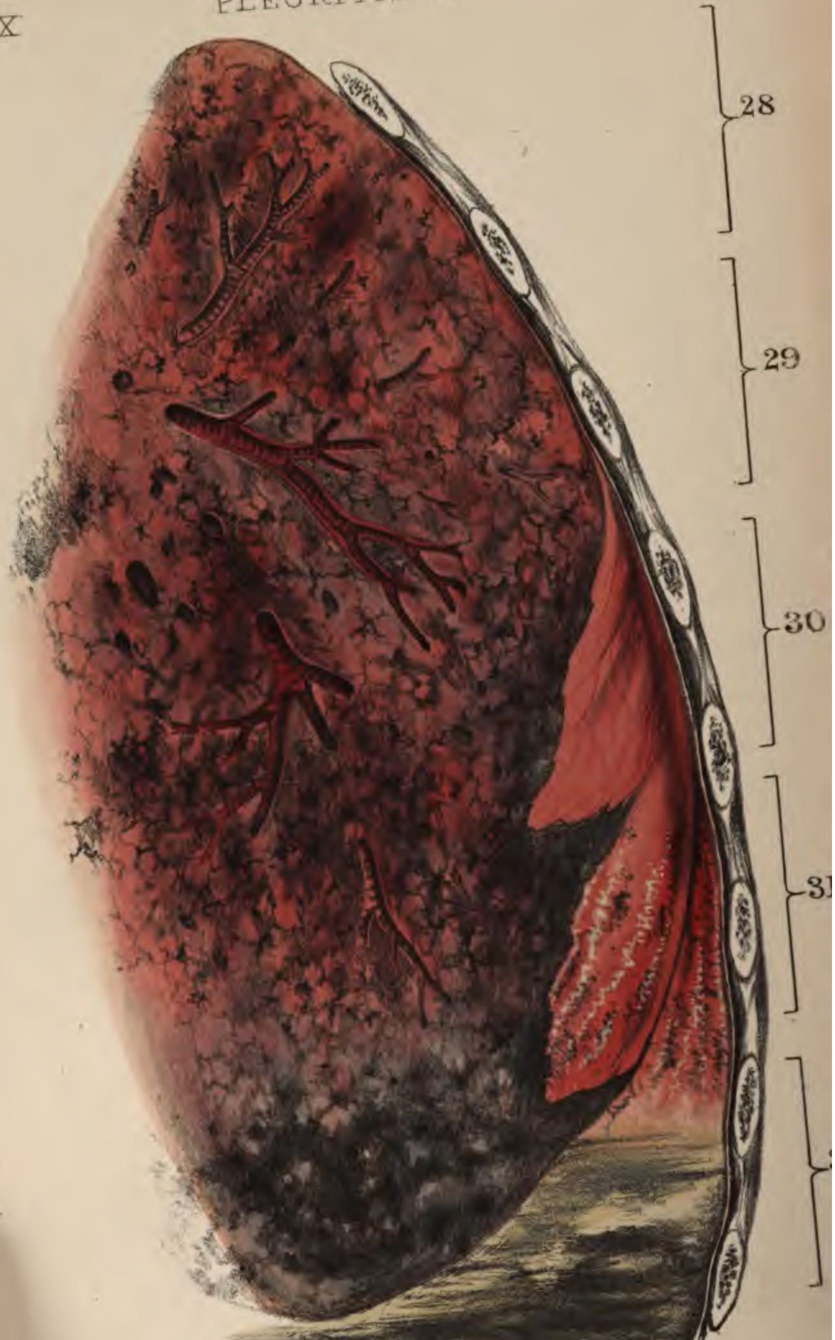

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PLATE IX.—PLEURISY, &c.

Figure 28.

Normal Lung, *with increased function.*

Costal movements increased in expansion and elevation.

Percussion. Undue resonance during inspiration.

Auscultation. Respiratory murmur increased in the intensity and duration of both sounds, the expiratory slightly in excess: an increase unattended with modification of any kind, either in respect of quality, softness, or liquidness. (The increased proportion of the expiratory sound is very slight.) Vocal resonance *slightly* increased in intensity.

Figure 29.

First Stage of Acute Bronchitis. *The bronchial mucous membrane vascular, dry, tumid,—diminishing the calibre of the tubes unequally.*

Percussion normal.

Auscultation. Respiratory murmur impaired in fullness, clearness, and softness, becoming harsh—especially the expiratory sound, which is prolonged. Rhonchus and sibilus constant or occasional.

Cough essential, frequent, dry,—may be hoarse, loud, ringing, paroxysmal. Sputa none, or white, adhesive, *finely frothed* mucus in small quantity.

Figure 30.

First Stage of Pleuritis. *Pleura vascular, rough, and dry. Sub-pleural cellular tissue injected, and tumid.*

Costal movements restricted by pain.

Percussion scarcely or not at all impaired.

Auscultation. Respiratory murmur weak, superficial, jerking. *No friction sound yet* (except in some cases unattended with pain).

Cough usual, but not essential; dry, short, small, suppressed. Sputa none, or a little viscid mucus.

Figure 31.

Second Stage of Pleuritis. *Slight sero-plastic exudation on the pleural surfaces.*

Vocal fremitus usually normal. If impaired it is in proportion to the amount of exudation. The vibration of pleural friction *may* be perceptible to palpation.

Percussion impaired in proportion to the amount of exudation.

Auscultation. *Pleural friction sound* accompanies expiration, inspiration, or both. Respiratory murmur weak, jerking, distant, or inaudible.

Cough and Sputa, see Pl. IX, fig. 30.

Figure 32.

Third Stage of Pleuritis. *Considerable sero-plastic exudation, separating the costal from the pulmonary pleura, compressing the lung, depressing the diaphragm, and displacing organs.*

Intercostal depressions obliterated, costal movements lost. Vocal fremitus lost.

Percussion perfectly dull, with increased resistance.

Auscultation. *No friction sound.* Respiratory sounds lost. Vocal resonance may be bronchophonic or lost. A peculiar tremulous bronchial voice, sometimes heard from the line of commencing dullness to a line at which all voice sounds are lost. Ægophony occasionally—especially in a line with the inferior angle of the scapula. (Heart sounds may be conducted.) Increased circumference of the affected side most marked round the false ribs.

Cough and Sputa, see Pl. IX, fig. 30.

Note.—Hydrothorax. *An effusion into the pleural sac of serum, free from the products of inflammation.*

For Signs see above (Pl. IX, fig. 32). It is usually double.

PLATE IX

PLEURITIS &c.

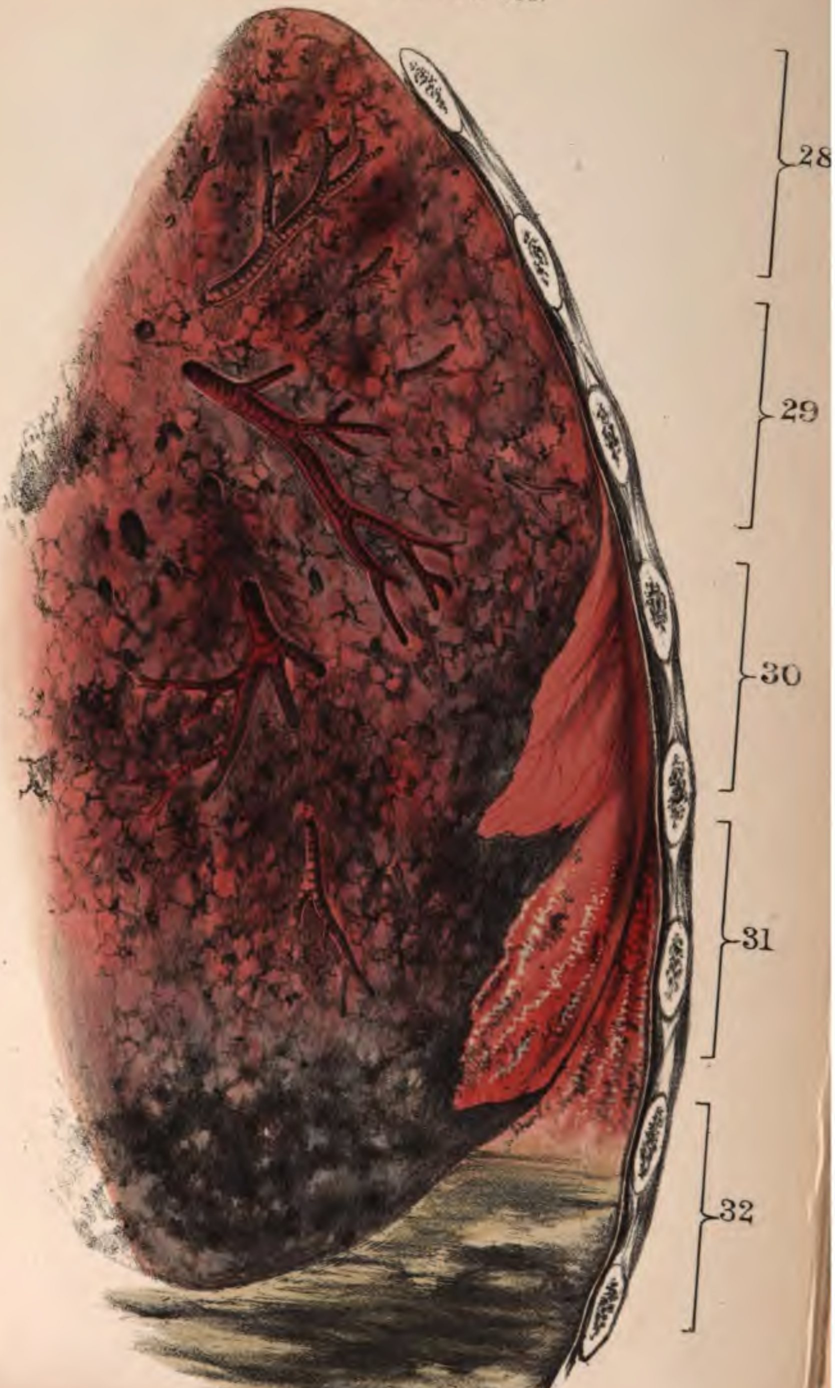


PLATE IX.—PLEURISY, &c.

FIGURE 28.

NORMAL LUNG, *with increased function.*

Costal movements increased in expansion and elevation.

PERCUSSION. Undue resonance during inspiration.

AUSCULTATION. Respiratory murmur increased in the intensity and duration of both sounds, the expiratory slightly in excess: an increase unattended with modification of any kind, either in respect of quality, softness, or liquidness. (The increased proportion of the expiratory sound is very slight.) Vocal resonance *slightly* increased in intensity.

FIGURE 29.

FIRST STAGE OF ACUTE BRONCHITIS. *The bronchial mucous membrane vascular, dry, tumid,—diminishing the calibre of the tubes unequally.*

PERCUSSION normal.

AUSCULTATION. Respiratory murmur impaired in fullness, clearness, and softness, becoming harsh—especially the expiratory sound, which is prolonged. Rhonchus and sibilus constant or occasional.

COUGH essential, frequent, dry,—may be hoarse, loud, ringing, paroxysmal. SPUTA none, or white, adhesive, *finely frothed* mucus in small quantity.

FIGURE 30.

FIRST STAGE OF PLEURITIS. *Pleura vascular, rough, and dry. Subpleural cellular tissue injected, and tumid.*

Costal movements restricted by pain.

PERCUSSION scarcely or not at all impaired.

AUSCULTATION. Respiratory murmur weak, superficial, jerking. *No friction sound yet* (except in some cases unattended with pain).

COUGH usual, but not essential; dry, short, small, suppressed. SPUTA none, or a little viscid mucus.

FIGURE 31.

SECOND STAGE OF PLEURITIS. *Slight sero-plastic exudation on the pleural surfaces.*

Vocal fremitus usually normal. If impaired it is in proportion to the amount of exudation. The vibration of pleural friction *may* be perceptible to palpation.

PERCUSSION impaired in proportion to the amount of exudation.

AUSCULTATION. *Pleural friction sound* accompanies expiration, inspiration, or both. Respiratory murmur weak, jerking, distant, or inaudible.

COUGH and SPUTA, see Pl. IX, fig. 30.

FIGURE 32.

THIRD STAGE OF PLEURITIS. *Considerable sero-plastic exudation, separating the costal from the pulmonary pleura, compressing the lung, depressing the diaphragm, and displacing organs.*

Intercostal depressions obliterated, costal movements lost. Vocal fremitus lost.

PERCUSSION perfectly dull, with increased resistance.

AUSCULTATION. *No friction sound.* Respiratory sounds lost. Vocal resonance may be bronchophonic or lost. A peculiar tremulous bronchial voice, sometimes heard from the line of commencing dullness to a line at which all voice sounds are lost. Ægophony occasionally—especially in a line with the inferior angle of the scapula. (Heart sounds may be conducted.) Increased circumference of the affected side most marked round the false ribs.

COUGH and SPUTA, see Pl. IX, fig. 30.

NOTE.—HYDROTHORAX. *An effusion into the pleural sac of serum, free from the products of inflammation.*

For Signs see above (Pl. IX, fig. 32). It is usually double.

PLATE X.—PNEUMOTHORAX, &c.

FIGURE 33.

PNEUMOTHORAX. *An abnormal collection of atmospheric air or gas in the cavity of the pleura, compressing the lung and displacing organs.*

Increased convexity of the affected side. Intercostal depressions obliterated. Elastic resistance increased. Vocal fremitus impaired or lost.

PERCUSSION purely tympanitic—often extending beyond the middle line. If the left side is affected, *heart* dulness is obscured, or lost.

AUSCULTATION. Respiratory sounds weakened by distance, or lost, according to the volume of the air or gas; but between the scapulæ an obscure bronchial murmur may usually be found. Frequently in perforative cases, amphoric or metallic character of cough, voice, and respiration—heard especially in the neighbourhood of the perforation of the lung, whether this is patent or not.

COUGH and **SPUTA** of the concurrent disease of the lung.

FIGURE 34.

THE WHOLE LUNG IS COMPRESSED. *At the upper part are several* EMPHYSEMATOUS CELLS, *ruptured on the lung surface, allowing the escape of air into the pleural cavity.*

At the middle part, TUBERCULOUS CAVITIES, *communicating with bronchi are ruptured on the lung surface, allowing the escape of air into the pleural cavity, and permitting purulent matter to drop into the fluid of empyema beneath.*

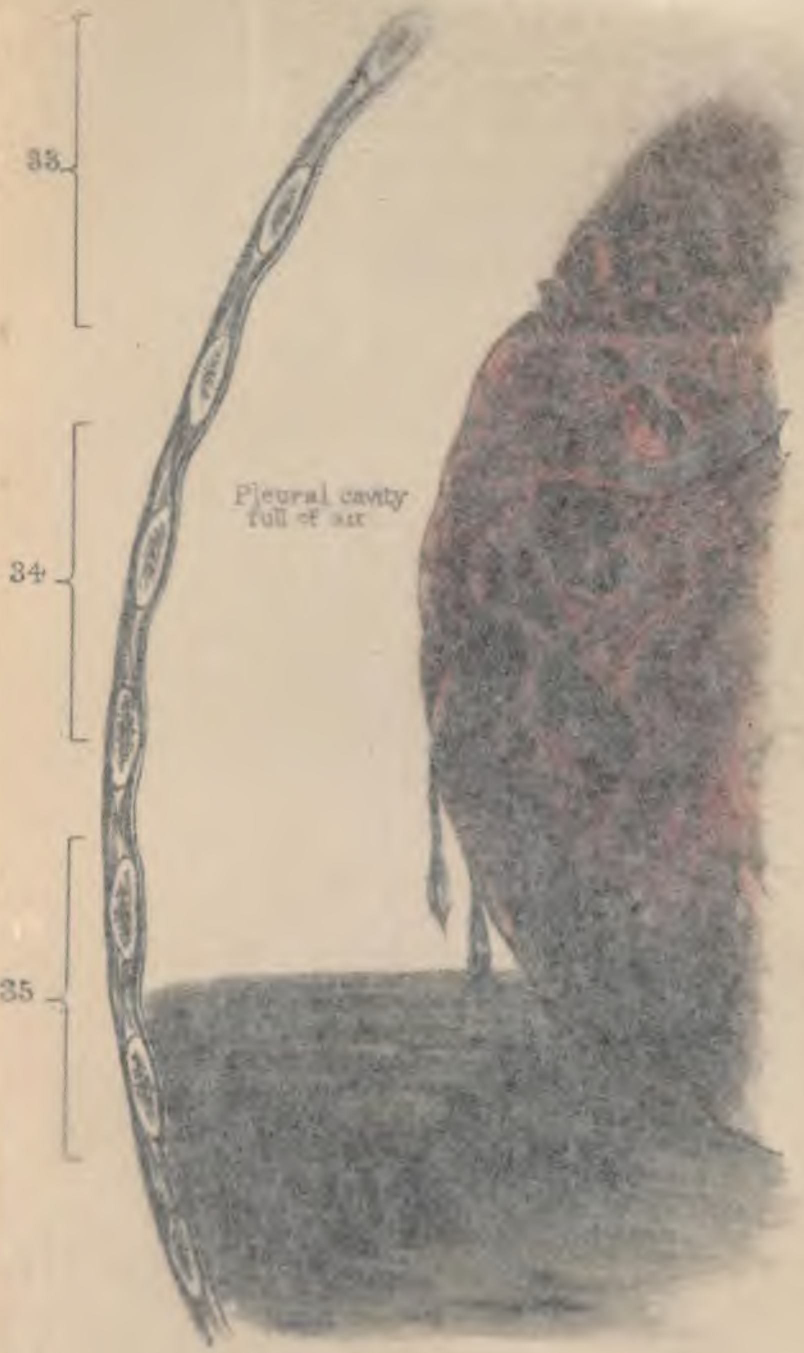
At the lowest part THE LUNG IS SIMPLY COMPRESSED.

FIGURE 35.

EMPYEMA WITH PNEUMOTHORAX. *Air and fluid at once in the cavity of the pleura.*

For Signs see fig. 33, and Pl. IX, fig. 32,—plus—succussion-sound when the chest is shaken; and perhaps *gutta cadens,* from drops of exudation falling on to the surface of the empyemic fluid,—heard usually after coughing or change of posture.

PNEUMOTHORAX &c. PLATE X.



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COROLLARY TO PLATES IX, X.

Physical signs of pleuritis—Explanation of the uncertain occurrence of friction sounds and the causes of their varieties—Hydrothorax—Importance of vocal fremitus; its disappearance explained—Absence of vesicular sounds, and uncertain occurrence of bronchial sounds explained—Old adhesions—Pneumothorax—Elastic chest-wall, tympanitic resonance—Influence of compression on the percussion sound of confined air or gas—Metallic tinkling; amphoric echo; gutta cadens; their acoustic conditions and distinctions—Pathological causes of pneumothorax—Supplementary, puerile, or compensatory respiration, a sign for alarm—First stage of bronchitis; its signs—Rhonchus, sibilus; their explanation.

Two series of changes are here represented, one external to the lung-substance, the other within its structure.

Figs. 28 and 34 are intimately connected with the interpleural changes; but fig. 29 has no necessary connexion with them, and is placed in this plate only for convenience, that the appearances of the interior of the bronchial tubes, and the characters of the respiration, may be compared with those of fig. 28.

Figs. 30, 31, and 32 show at a glance the physical conditions upon which the acoustic changes depend in the progress of pleuritic inflammation. In fig. 30 no exudation has yet occurred, and usually *no friction sound is heard*—the vascular and tumid state of the membrane not always rendering it sufficiently rough to produce an audible sound, as the two surfaces pass over one another. It is to be remembered, however, that the pleura in this stage is extremely tender, and the movements of respiration consequently attended with so much pain that they are suppressed as completely as possible; the inflamed surfaces, therefore, scarcely move upon each other, and very little opportunity occurs for the production of a friction sound. It can hardly be doubted that such a sound would be produced in most cases by the rubbing together of the dry and injected serous membrane, if this occurred with sufficient freedom and force.

But the dry state is of very short duration, and, unless speedily resolved, passes into the next, in which inflammatory exudation takes place, and *a friction sound is established* by the conditions shown in fig. 31. So long as the costal and pulmonary pleuræ are not too far separated to allow of impact between their surfaces, now roughened by plastic deposit, a friction sound may be heard; but on examining the plate it will be evident how slight a variation in the physical conditions might cause the sound to be lost, or again to become audible—a little less expansion of the lung might fail to bring the surfaces in contact—a little more might rub them effectually together—a little arrest in the process of exudation might allow them to play freely and audibly upon each other—a little increase of the fluid might separate them so completely that all sounds of their movement would be lost.

This effusion may go on until the chest-wall is distended, its intercostal depressions effaced, and the diaphragm depressed, while the lung is subjected to so much pressure by the fluid that the air is driven from it and prevented from returning (see fig. 32). If the left side is the seat of the disease the heart may be pushed from its place over to the opposite side; or the liver may be depressed below its boundaries if the disease is on the right side of the chest.

In the serous effusion of hydrothorax all these changes, shown in fig. 32, may take place, but *no friction sound is produced from first to last,* because the membrane is not rendered dry by inflammation, or roughened by plastic exudation, but simply bathed in a watery fluid.

In Plates I, II, and III, where lung-substance consolidated by interstitial deposits comes closely in contact with the chest-wall, the *vocal fremitus* is abnormally increased. In Plates IX and X, on the contrary, so soon as any amount of fluid collects in the pleural sac, the vocal fremitus begins to be impaired, and as the fluid increases speedily disappears altogether.

This is a sign of the utmost practical value, marking as it does a distinct difference between the phenomena produced by pleuritic effusion and those due to lung-consolidation. In both diseases there is dulness on percussion, in both resistance to the percuting finger, but vocal fremitus is present in the one case, absent in the other.

This increased vibration of the chest-wall is explained in lung-consolidations by the improved conducting power of the dense lung, and its close contact with the thoracic parietes. In pleuritic effusion, it is true that the lung is increased in density, but this change is caused by pressure from without, which not only renders totally airless the vesicular structure, and prevents the admission of air to the smaller bronchial passages from which vocal vibrations might reach the compressed lung, but drives back the whole source of vibration from the chest-wall.

Knowing, as we do, that fluids may be readily thrown into vibration, under ordinary circumstances, it is not clear, perhaps, at first, why this is not the case in pleuritic effusion. The fact is, however, explained when we consider the very slight compressibility of water, and that while the lung is held back by a watery fluid, compression of that fluid is constantly kept up by the attempted expansion of the lung during respiration; the result being that both the fluid and the lung-substance are subjected to pressure, and held in a state of comparative rest.

The *absence of vesicular respiratory sounds* in fig. 32 cannot excite surprise after considering the condition of the vesicular lung-substance, which is, in fact, temporarily destroyed. And that *bronchial sounds* should be *only occasionally heard* is what might be expected from the distance to which the bronchi are removed from the chest-wall, the obliteration of all those susceptible of compression, and the restricted vibration of the intervening media already described.

The same circumstances also explain the fact that bronchial sounds, when audible, are most frequently detected as we approach the surface of the effused fluid—where its movements are less restricted, the lung less compressed, and nearer to the chest-wall; and we understand why these sounds are plainly heard when any portion of lung happens to be held in contact with the ribs by pleuritic adhesions.

The individual characters of *pleural friction sounds* may vary—with the degree to which the opposing surfaces are roughened, with the consistence of the exudation, and with the extent to which the respiratory movements are restricted by pain. Thus, in the first stage of dry, tumid, vascularity, if any sound is produced, its character is usually rather soft and grazing; in the second stage, ridges of adhesive, sero-plastic, exudation may give a grating or sawing sound; and in chronic pleurisy, when the interpleural matter has become variously altered in consistence, and more or less adhesion has occurred between different portions, the friction sound may acquire creaking, rumbling, and other modifications of character.

In examining cases of chronic pleurisy or of the acute disease in persons who have suffered from a previous attack, it is necessary to remember that adhesions may have been effected between the pulmonary and costal pleuræ, which, by restricting movement, may interfere with the production of friction sounds; and when the pleural cavity is becoming distended with liquid effusion, the lung, in other parts pushed back from the chest-wall, may, at the points of adhesion, be held in contact with the ribs, and thus complicate the diagnosis (see p. 106).

In Plate X, fig. 33 (Pneumothorax), the lung is driven back towards the spine, and its tissue compressed by a highly elastic and compressible form of matter. The resistance of the chest-wall to the percuting finger is very different from that in Plate IX, fig. 32. Although, as in that case, the "*intercostal spaces are distended,*" their "*elasticity is augmented*" instead of being lost. The resonance on percussion is "*purely tympanitic,*" differing in pitch with the quantity of gaseous fluid effused, that is to say, with the degree of compression to which it is subjected. In the most exaggerated cases its density may be so much increased, and its vibrations consequently so much restricted, that it becomes difficult to identify the sound as the resonance of percussed air. But under ordinary circumstances the resonance of pneumothorax is of pure tympanitic timbre, and constitutes the most prominent and typical physical sign of the disease.

In Plate VI, fig. 21, the resonance is "tympanitic;" in Plate VII, fig. 23, "weakly tympanitic;" in Plate VII, fig. 24, "morbidly clear, or sometimes tympanitic;" in Plate IX, fig. 28, the "resonance is in excess." In each of these instances of excessive resonance the same physical condition is present, although differing in degree and in its cause—a volume of air larger, in proportion to the solid structures, than is normal, has been brought within reach of the percussion stroke (see pp. 11, 64, 65).

The mention of "*amphoric or metallic character of respiration and voice,*" in Plate X, fig. 33, and of "*gutta cadens,*" fig. 35, affords an opportunity of pointing out what appear to be the distinctive acoustic conditions of these sounds.

The physical conditions consistent with the production of "*metallic tinkling*" have already been discussed, and may be thus enumerated. A cavity of considerable size, with dense vibratile walls, containing air; and the impact of a blast of air upon some portion of its walls, usually either upon the edge of an opening into the cavity, or upon the inner surface of its parietes (see pp. 12, 24, 63).

If the walls of such a cavity are *damped* in their vibrations, or are too thick, or not sufficiently dense, or if a blast of air into the cavity is not forcible enough, metallic tinkling, may not be excited in its walls, and reflection alone, or combined with imperfect metallic resonance, may take place, and produce a sound of the peculiar character known as "*amphoric echo*," (see p. 18).

A drop of fluid falling from a height on to the surface of a fluid, in a space bounded by reflecting or vibratile walls, containing air, produces a peculiar and characteristic sound to which the name "gutta cadens" may be appropriately applied (see pp. 12, 63).

The acoustic conditions may be intermediate between those necessary to the true metallic tinkling and those essential to amphoric echo—producing sounds of intermediate character; while the conditions necessary to gutta cadens include those of both the other sounds; and hence not improbably has arisen that confusion between gutta cadens, metallic tinkling, and amphoric echo, and the theories of their production, so commonly met with among teachers of auscultation.

The possible causes of pneumothorax are very numerous, but the probable and usual causes of the non-traumatic form are seen in Plate X, fig. 34; to which may be added, the discharge of empyema through the lung-surface into the bronchial tubes.

Fig. 35 illustrates one of the pathological states to which may be due the essential acoustic conditions of gutta cadens (see p. 63), and also shows the conditions which are necessary to the production of the sound of "*succussion*," or splashing (see pp. 12, 13), the concussion of a fluid with a fluid, or with a solid, or with both, beneath an atmosphere.

Plate IX, fig. 28, represents a portion of healthy lung upon which increased function has devolved compensatory to impaired function of some other portion: illustrating that grand principle of compensation which pervades the universe. In all chest diseases, by which the breathing power of one part of the lungs is diminished, an undue stress is thrown upon some other part which is more healthy. If a whole lung is diseased, the other lung attempts the double duty; if only a part of one lung is impervious to air, the rest of that lung shares with the sound organ the increase of function. The character of respiration, voice, and cough sounds is altered; but the principal change is observable in the *intensity*, accompanied by a necessary increase in *duration*, but not proportionate to the intensity. A very slight change of *rhythm* is likewise present, the expiratory sound being *slightly* disproportionate in length, consequent upon the want of power in the lung itself to expel the abnormal quantity of air thrown into it at each inspiratory act (see pp. 28, 29, 54).

No other alteration from the quality of healthy respiratory murmur takes place. Nothing can be more important in the study and practice of auscultation than a due appreciation of this change in the sounds. It ought to be familiar to all, because it can always be heard by listening to a healthy chest during forced respiration—as after energetic

CHAPTER VII.

CONCLUDING REMARKS.

General practical lesson to be learned from the plates—Qualifications of a physician—The wisdom of suspending judgment if the evidence is not complete—Insufficiency of physical signs as the sole basis of diagnosis—Examples of groups of pathological conditions requiring analysis.

A CAREFUL review of the foregoing plates, their marginal explanations and corollaries, must impress the thoughtful mind with this important lesson, which cannot be too constantly borne in mind — that *inspection*, *mensuration*, *palpation*, *percussion*, and *auscultation* are means by which most valuable information may be gained of the conditions of organs within the chest; but that, either singly or combined, they are limited in their power to the revelation of certain physical conditions, which require the assistance of other knowledge than any of these means can afford, to give to each condition its true pathological meaning. The wise and skilful physician must have educated not only the ear, but every organ by which he can take cognizance of external things; his intellect must have been prepared to receive their impressions truthfully, to test their value, to arrange them, and to reason upon them; he must have practised the judgment in estimating the weight of evidence, restricting the flights of fancy, and in seizing with promptitude upon the just conclusion. But it should never be forgotten that the greatest wisdom may be shown by not coming to any conclusion at all on insufficient evidence.

It has been seen in the preceding pages that the evidence of physical signs alone is often insufficient to form the basis of a safe diagnosis :—kept to its proper place, it cannot be over estimated, but it must not assume to put aside other sources of information, upon which the physical signs depend for their interpretation. Thus, an assemblage of signs may be detected plainly indicating increased density of the structures within the chest, but this change in the physical condition may be due to a number of very different pathological states, and he who should conclude that dullness on percussion, bronchial breathing, and bronchophony, indicated tuberculous consolidation of the lung, might as easily be wrong as right; whereas by bringing together the physical signs, and the results of clinical experience in all the other features of disease, those physical signs will each acquire a special force and meaning, and may then form the basis of a safe and accurate diagnosis.

To enter upon those clinical histories and general symptoms referred to in passing, would carry us far beyond the intended limits of this work; but I venture to recommend the student to analyse each plate, to compare the structural changes depicted with the corresponding physical signs; and wherever these are not sufficient of themselves to identify the different pathological conditions, to search out the general symptoms necessary to complete a distinctive diagnosis, in some of those excellent works devoted to this part of the subject; of which he cannot select a better than the very careful and comprehensive treatise by Dr. Walshe, to which reference has already been frequently made.

As examples of subjects especially requiring such analysis and investigation, let me direct attention to the following groups, in each of which certain physical signs are common to several physical states differing seriously in their pathological nature.

1st Group.

Isolated interstitial tuberculous granulations. Pl. I, fig. 1.
First stage of acute bronchitis. Pl. IX, fig. 29.

2d Group.

Second stage of Pneumonia. Pl. II. fig. 7.
Third Stage of Pneumonia. Pl. IV, fig. 15.
Conglomerated interstitial tuberculous granulation. Pl. I, fig. 2.

3d Group.

Bronchiectasis. Pl. VIII, fig. 25.
Tuberculous excavations. Pls. VI and VII.
Pneumonic abscess, the purulent contents more or less evacuated. Pl. VIII, fig. 27.

4th Group.

Second stage of tuberculous deposit. Pl. V, fig. 16.
Chronic bronchitis. Pl. IV, fig. 14.
Old apoplectic coagula, softening. Pl. V, fig. 17.

5th Group.

In which *very similar* physical signs are in danger of being confounded and mistaken for each other.

Œdema of the lung. Note to fig. 6, Pl. II.

Second Stage of Capillary Bronchitis. Note to fig. 13, Pl. IV.

First stage of Pneumonia. Pl. II, fig. 6.

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A CLASSIFIED INDEX

TO

MR. CHURCHILL'S CATALOGUE.

ANATOMY.

PAGE
Anatomical Remembrancer .. 3
Beale on Liver 5
Hassall's Micros. Anatomy .. 14
Holden's Human Osteology .. 15
Jones' and Sieveking's Pathological Anatomy 17
Maclise's Surgical Anatomy .. 19
Paget's Catalogue 21
Sibson's Medical Anatomy .. 25
Toynbee's Catalogue 28
Wheeler's Handbook 30
Wilson's Anatomy 31

CHEMISTRY.

Abel & Bloxam's Handbook .. 4
Bowman's Practical Chemistry 7
Do. Medical do. .. 7
Chalmers' Electro-Chemistry .. 8
Fownes' Manual of Chemistry .. 12
Do. Actonian Prize 12
Do. Qualitative Analysis .. 12
Do. Chemical Tables 12
Fresenius' Chemical Analysis .. 12
Galloway's First Step 12
Do. Analysis 12
Do. Diagrams 12
Griffiths' Four Seasons 13
Horsley's Chem. Philosophy .. 16
Jones.—Mulder on Wine 17
Odling's Practical Chemistry .. 21
Plattner on Blowpipe 22
Speer's Pathol. Chemistry .. 26

CHOLERA.

Acland on Cholera at Oxford .. 3
Baly and Gull—Reports 4
Snow on Cholera 25

CLIMATE.

Francis on Change of Climate .. 12
Hall on Torquay 14
Haviland on Climate 14
Lee on Climate 18
Martin on the Undercliff 19
Martin (J. R.) on Tropical .. 20

DEFORMITIES, &c.

Bigg on Deformities 6
Bishop on Deformities 6
Do. Articulate Sounds .. 6
Brodhurst on Spine 7
Do. on Clubfoot 7
Hare on Spine 14
Hugman on Hip Joint 16
Inman on Spine 16
Tamplin on Spine 27

DENTISTRY.

PAGE
Blundell's Painless Extraction . 7
Clark's Odontalgist 9
Gray on the Teeth 13
Odontological Soc. Transactions 21

DISEASES of the URINARY and GENERATIVE ORGANS, and SYPHILIS.

Acton on Reproductive Organs 3
Coote on Syphilis 9
Coulson on Bladder 10
Do. on Lithotomy 10
Egan on Syphilis 11
Judd on Syphilis 17
Milton on Gonorrhœa 20
Parker on Syphilis 21
Todd on Urinary Organs 28
Wilson on Syphilis 31

DISEASES OF WOMEN AND CHILDREN.

Bennet on Uterus 5
Do. on Uterine Pathology .. 5
Bird on Children 6
Brown on Women 7
Do. on Scarlatina 7
Eyre's Practical Remarks .. 11
Hood on Crowing 16
Lee's Ovarian & Uterine Diseases 18
Lee on Diseases of Uterus .. 18
Do. on Speculum 18
Roberton on Women 23
Rowe on Females 24
Smith on Leucorrhœa 25
Tilt on Diseases of Women .. 27
Do. on Change of Life 27
Underwood on Children 28
West on Women 29

HYGIENE.

Armstrong on Naval Hygiene 3
Beale's Laws of Health 4
Do. Health and Diseases .. 4
Bennet on Nutrition 5
Blundell's Medicina Mechanica 7
Carter on Training 8
Cornaro on Long Life 9
Hartwig on Sea Bathing 14
Do. Physical Education 14
Hufeland's Art 16
Lee's Watering Places of England 18
Do. do. Germany, France, and Switzerland .. 18
Lee's Rhenish Watering Places 18
Pickford on Hygiene 22
Robertson on Diet 23
Roth on Movements 24
Rumsey's State Medicine 24
Van Oven's Decline of Life .. 29
Wilson on Healthy Skin 31
Do. on Mineral Waters .. 31

MATERIA MEDICA and PHARMACY.

PAGE
Bateman's Magnacopia 4
Beasley's Formulary 5
Do. Receipt Book 5
Do. Book of Prescriptions 5
Lane's Materia Medica 18
Pereira's Selecta e Præscriptis 22
Pharmacopœia Londinensis .. 22
Prescriber's Pharmacopœia .. 22
Royle's Materia Medica 24
Spurgin's Materia Medica 26
Squire's Pharmacopœia 26
Steggall's Materia Medica .. 26
Do. First Lines for Chemists 26
Stowe's Toxicological Chart .. 26
Taylor on Poisons 27
Wittstein's Pharmacy 30

MEDICINE.

Adams on Rheumatic Gout .. 4
Addison on Supra-Renal Capsules 4
Addison on Cells 3
Alexander on Rheumatism .. 3
Arnott on a Local Anæsthenic 3
Barclay on Diagnosis 5
Barlow's Practice of Medicine 4
Basham on Dropsy 5
Beale on Urine 5
Billing's First Principles 6
Bird's Urinary Deposits 6
Bird on Charcoal 6
Brinton on Ulcer 7
Budd on the Liver 7
Do. on Stomach 7
Camplin on Diabetes 8
Chambers on Digestion 8
Davey's Ganglionic 10
Eyre on Stomach 11
Fuller on Rheumatism 12
Gairdner on Gout 12
Garrett on E. and N. E. Winds 12
Granville on Sudden Death .. 13
Gully's Simple Treatment .. 13
Habershon on Stomach 13
Hall on Apnœa 14
Hall's Observations 14
Harrison on Lead in Water .. 14
Headland on Medicines 15
Hooper's Medical Dictionary .. 16
Hooper's Physician's Vade-Mecum 13
Jones' Animal Chemistry .. 17
Lugol on Scrofula 19
Peacock on Influenza 21
Do. on Heart 21
Pym on Yellow Fever 22
Roberts on Palsy 24
Robertson on Gout 23
Savory's Compendium 24
Semple on Cough 24
Shaw's Remembrancer 25
Steggall's Medical Manual .. 26
Do. Gregory's Conspectus 26
Do. Celsus 26

MEDICINE—*continued.*

PAGE
Thomas' Practice of Physic .. 27
Thudichum on Urine 27
Wegg's Observations.. 29
Wells on Gout 30
What to Observe 19
Whitehead on Transmission .. 30
Williams' Principles 30
Wright on Headaches 30

MICROSCOPE.

Beale on Microscope in Medicine 5
Do. How to Work 5
Carpenter on Microscope 8
Schacht on do. 24

MISCELLANEOUS.

Acton on Prostitution 3
Atkinson's Bibliography 4
Bascome on Epidemics 5
Bryce on Sebastopol 8
Cooley's Cyclopædia 9
Forbes' Nature and Art in Disease 11
Gully on Water Cure.. 13
Guy's Hospital Reports 13
Haycock's Veterinary 15
Lane's Hydropathy 18
Marcet on Food 19
Massy on Recruits 20
Part's Case Book 21
Pettigrew on Superstitions .. 22

NERVOUS DISEASES AND INDIGESTION.

Anderson on Nervous Affections 4
Arnott on Indigestion 3
Carter on Hysteria 8
Child on Indigestion 8
Downing on Neuralgia 11
Hunt on Heartburn 16
Lobb on Nervous Affections .. 19
Radcliffe on Epilepsy 23
Reynolds on the Brain 23
Rowe on Nervous Diseases .. 24
Sieveking on Epilepsy 25
Todd on Nervous System.. .. 28
Turnbull on Stomach 28

OBSTETRICS.

Barnes on Placenta Prævia .. 4
Davis on Parturition.. 11
Johnston & Sinclair's Midwifery 17
Lee's Clinical Midwifery 18
Pretty's Aids during Labour .. 22
Ramsbotham's Obstetrics.. .. 23
Do. Midwifery.. .. 23
Smellie's Obstetric Plates.. .. 25
Smith's Manual of Obstetrics .. 25
Do. Periodoscope.. 25
Swayne's Aphorisms.. 26
Waller's Midwifery 29

OPHTHALMOLOGY.

PAGE
Cooper on Near Sight 9
Dalrymple on Eye 10
Dixon on the Eye 11
Hogg on Ophthalmoscope .. 15
Holthouse on Strabismus 15
Do. on Impaired Vision 15
Jacob on Eye-ball 16
Jago on Ocular Spectres 16
Jones' Ophthalmic Medicine .. 17
Do. Defects of Sight 17
Do. Eye and Ear 17
Nunneley on the Organs of Vision 21
Walton on Ophthalmic 29

PHYSIOLOGY.

Carpenter's Human 8
Do. Comparative 8
Do. Manual 8
Cottle's Human 10
Hilton on the Cranium 15
Richardson on Coagulation .. 23

PSYCHOLOGY.

Bucknill and Tuke's Psychological Medicine 7
Burgess on Madness 7
Burnett on Insanity 9
Conolly on Asylums 9
Davey on Nature of Insanity .. 10
Dunn's Physiological Psychology 11
Hood on Criminal Lunatics .. 16
Jacobi on Hospitals, by Tuke .. 28
Knaggs on Criminal Lunatics.. 17
Millingen on Treatment of Insane 20
Monro on Insanity 20
Do. Private Asylums 20
Noble on Psychology 20
Do. on Mind 20
Williams (J.) on Insanity .. 30
Williams (J. H) Unsoundness of Mind 30
Winslow's Lettsomian 31
Do. Law of Lunacy .. 31

PULMONARY and CHEST DISEASES, &c.

Addison on Healthy and Diseased Structure 3
Billing on Lungs and Heart .. 6
Blakiston on the Chest 6
Bright on the Chest 7
Cotton on Consumption 10
Do. on Stethoscope 10
Davies on Lungs and Heart .. 10
Dobell on the Chest 11
Fenwick on Consumption.. .. 11
Laennec on Auscultation 17
Madden on Consumption 19
Markham on Heart 20
Richardson on Consumption .. 23
Skoda on Auscultation 20
Thompson on Consumption .. 27
Wardrop on the Heart 29
Weber on Auscultation 29

SCIENCE.

PAGE
Bird's Natural Philosophy .. 6
Burnett's Philosophy of Spirits 8
Garner's Eutherapeia 13
Hardwich's Photography.. .. 14
Hinds' Harmonies 15
Holland on Appendages 15
Jones on Vision 17
Do. on Body, Sense, and Mind 17
Mayne's Lexicon 19
Price's Photographic Manipulation 22
Nourse's Students' Tables .. 21
Rainey on Shells 23
Reymond's Animal Electricity 23
Taylor's Medical Jurisprudence 27
Vestiges of Creation 28
Sequel to ditto 28
Unger's Botanical Letters .. 28

SURGERY.

Arnott on Urethra 3
Ashton on Rectum 4
Bellingham on Aneurism.. .. 6
Bigg on Artificial Limbs 6
Bishop on Bones.. 6
Chapman on Ulcers 9
Do. Varicose Veins 9
Cooper (Sir A.) on Testis 10
Cooper's (B.) Surgery 9
Do. (S.) Surg. Dictionary 9
Curling on Rectum 10
Do. on Testis 10
Druitt's Surgery 11
Fergusson's Surgery.. 11
Gay on Femoral Rupture.. .. 13
Do. on Ulcers.. 13
Harrison on Stricture 14
Higginbottom on Nitrate of Silver 15
Hodgson on Prostate.. 15
Laurence on Cancer 18
Lawrence on Ruptures 18
Lee on Hæmorrhoids 18
Liston's Surgery.. 18
Macleod's Surgery of the Crimea 19
Maclise on Fractures.. 19
Nottingham on the Ear 20
Nunneley on Erysipelas 21
Pirrie on Surgery 22
Skey's Operative Surgery .. 25
Smith on Stricture 25
Snow on Chloroform.. 25
Steggall's Surgical Manual .. 26
Teale on Amputation 27
Thompson on Stricture 27
Do. on Prostate 27
Wade on Stricture 29
Watson on the Larynx 29
Wilson on the Skin 31
Do. Portraits of Skin Diseases 31
Yearsley on Deafness 31
Do. on Throat 31

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